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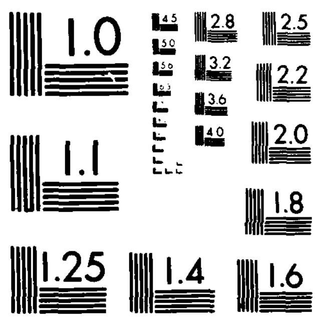

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Roland:

A Case for or Against NATO Standardization?

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ROLAND: A CASE FOR OR AGAINST NATO STANDARDIZATION?

by

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Colonel Daniel K. Malone, USA

Senior Research Fellow
Research Directorate

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Dedicated to Major General Theodore Antonelli, USA, Commandant of the Industrial College of the Armed Forces, 1975-1978, a fine gentleman, good friend, and veteran of 37 years of combat, command, and staff service spanning three wars. A specialist in logistics and a member of the American Defense Preparedness Association, General Antonelli has devoted years of study and thought to the problems of industrial mobilization and military-industrial relationships. His wise counsel and active encouragement have contributed a great deal to this study.

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FOREWORD

A key Alliance security policy issue that has been the focus of vigorous debate is the feasibility and desirability of rationalization, standardization, and interoperability (RSI) of weapons and other materiel to enhance NATO military effectiveness. This question is addressed by Colonel Malone in this study through an in-depth examination of one cooperative Allied weapon acquisition project—the ROLAND air defense system.

ROLAND is the first major European-designed weapon to be manufactured within the US industrial system, thus reversing the traditional direction of past technology transfer. Transferring ROLAND's technology, however, proved to be an enormously complex endeavor. Different political processes, disparate bureaucratic procedures, divergent military doctrines, and hundreds of individual steps on both sides of the Atlantic had to be harmonized to overcome the obstacles and begin production.

The United States and its Allies acquired valuable experience during this complex venture into standardization through technology transfer. As Colonel Malone's study reveals, this experience should facilitate similar Allied undertakings and expand our mutual ability to plan, design and develop a more integrated approach to the military challenges of the future.

R. G. GARD, JR.
Lieutenant General, USA
President

ABOUT THE AUTHOR

Colonel Daniel K. Malone is an expert in the area of project management of high technology military projects. He wrote this study while a Senior Research Fellow with the National Defense University. A graduate of West Point, Colonel Malone attended the Army Command and General Staff College and received a master's degree in business administration from Syracuse University. His career has followed a pattern of research and development, logistics, intelligence, and operations research assignments to include service as a Division Chief, Directorate of Logistics, Organization of the Joint Chiefs of Staff; Commander, Scranton Army Ammunition Plant; and Assistant Army Attaché, American Embassy, Moscow. The author of several journal articles on air defense weaponry, Colonel Malone served in both Korea and Vietnam and is currently serving as Director of Armaments and Standardization, US Mission, NATO.

PREFACE

I would like to express my thanks to Lieutenant General Robert G. Gard, Jr., President, National Defense University, and Major General Theodore Antonelli, Commandant, Industrial College of the Armed Forces, 1975-78, for their sponsorship of this study. *Appreciation is extended to various officials of the Department of* Defense, especially Brigadier General Frank Ragano, ROLAND Project Manager, and his staff; and Lieutenant General D. R. Keith, Deputy Chief of Staff for Research, Development and Acquisition, US Army, and his staff for their excellent and open cooperation; along with others in the United States and foreign governments who granted interviews or assisted in various ways. Thanks are due Mr. Gerald Strome of Hughes Aircraft Company, and Mr. G. C. King of Boeing Corporation, for their open discussion, and their time, which enabled the extension of this study to the dimensions of both the military user and the industrial developer. Special gratitude is also merited by the American Defense Preparedness Association, whose seminars and contacts provided much of the perspective essential to the writing of this report, which is intended as curriculum material for the Industrial College of the Armed Forces. Particular thanks are due Dr. I. B. Holley, Professor of History, Duke University, for the idea and considerable direction which enabled the writing of Chapter IX, and to Ms. Evelyn Lakes, Editor at the National Defense University, for her continuous assistance in a variety of research and editorial endeavors.

Much of the study stems from personal interviews with parties concerned with ROLAND, most of whom asked to remain unnamed. Their varying perspectives may constitute a weakness in research methodology for so current a topic. However, these same differences of opinion, reflected in the report, contribute immeasurably to portraying ROLAND's most serious obstacle, that so many key people viewed the project in so many different ways. Thanks are due the forthright participation of all concerned. Their commentary alone enabled the writing of this report from the point of view of people at work today so that others may benefit tomorrow in similar novel ventures.

Responsibility for any shortcoming or error is my own. The views expressed herein reflect those of the author and do not necessarily reflect official views of the National Defense University or any of the organizations named.

DANIEL K. MALONE
Colonel, USA

ROLAND:
A CASE FOR OR AGAINST NATO STANDARDIZATION?

INTRODUCTION

Money, politics, and military preparedness: these three factors rank among the strongest determinants shaping events and outcomes within the Western socioeconomic system. When these factors converge in a major Allied cooperative weapon acquisition project, the sheer complexity of modern technology results in the project becoming a microcosm of that socioeconomic system. The conflicts and the coincidences of the three vectors of money, politics, and preparedness for war become especially sharp; add to the foregoing the varying internal and external politico-economic objectives of the several nations involved in the joint weaponization effort, and the possibilities for competing objectives and cross purposes multiply. Seeking out the path to success means finding where the three vectors coincide or tend to neutralize one another; this is a particularly difficult task for a project manager or corporate officer responsible for delivering hardware to the field.

The ROLAND air defense system was developed by the French/German consortium Euromissile and licensed for US production by co-licensees Hughes Aircraft Company and Boeing Aerospace (hereafter referred to as Hughes and Boeing), provides a unique example of such a project. ROLAND today represents the most advanced existing concept in mobile, all-weather missile systems for defense against low-flying aircraft. ROLAND mounts an acquisition radar along with its unique optical and radar guidance systems together with all power supplies, two missiles and eight reloads, all on a single vehicle ~~(see Appendix A)~~. Projected plans call for ROLAND to be fielded as a major contributor to NATO air defenses in the 1980's, capable of maneuvering with forward tactical forces and deployable in a density which could (idealized, of course) shoot down several thousand attacking aircraft in less than 5 minutes.

The three nations involved with ROLAND, two fully participating NATO members and one partially participating member, as well as four corporations—variously public, private, semiprivate, and government-controlled—encompass an arena sufficiently large for the full scope of differing political, economic, and military objectives to have free play. Moreover, in response to a

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longstanding complaint by European NATO members demanding a true "two-way street" in weapons procurement, ROLAND, as the Army's first major European-designed NATO weapon to be manufactured in the United States, paved a major segment of that contentious road. Because similar technology transfers from Europe to the United States can be expected to continue, much can be learned from following the course set by ROLAND.

The "two-way street" in arms transfers was not the only background against which the US Army decided to procure ROLAND. The decision was made amidst a set of trends which go to the heart of problems of coalition warfare and the future survivability of our social system relative to the Marxist-Leninist coalition we presently face.

The increased complexity and cost of weapons in all free enterprise states; the competitive demands for money between NATO defense and the internal social programs of each NATO member; the competitive demands in the United States to prepare either for a large-scale mechanized war in Europe or for a brushfire "helicopter war," such as that in Vietnam; the general political malaise of European governments, rendered inflexible by leftist or Communist opposition; the general economic recession following the 1973 Arab-Israeli war; and the shift in the balance of NATO and Warsaw Pact nuclear and conventional military power—all played a role in bringing to fruition the decision on ROLAND.

Through the ebb and flow of the ROLAND project evolution, contractor selection, and subsequent efforts to resolve major problems, the weapon emerges as a powerful addition to NATO air defense. Despite the many interpersonal and even international controversies along the way, ROLAND's success will bear out the superior military ability of a socioeconomic system infused with the optimism of Keynes and Rousseau over those founded on the pessimism of Marx and Lenin.

The study and generally each chapter are intended to be self-contained. Those unfamiliar with "Rationalization, Standardization, and Interoperability" (RSI) and policies designed to achieve such properties will find chapters 1 and 3 informative. However, others will find that scanning, or even skipping those chapters, detracts nothing from the remainder. Chapter 2, concerning evolution of the military requirement for a ROLAND-type weapon, answers a question posed by a corporate executive, "Would there be a need for ROLAND were it

not for the political requirements of RSI?" Consequently, chapter 2 may interest a wider readership than other discussions of how the Army develops requirements for weapons, but it also can stand alone for those who are more interested in the tactical aspects than in the technical aspects of the ROLAND project to be found in later chapters. The author hopes the final chapter will prove entertaining as well as informative to all readers interested in ROLAND's progress and the prognosis for similar projects.

CHAPTER I

ROLAND, THE NATO COALITION, AND STANDARDIZATION

Improved standardization has been a long-recognized means to the end of improved NATO military preparedness. In 1949, following establishment of the North Atlantic Treaty Organization (NATO), the treaty's signators created a Military Production and Supply Board to promote "coordinated production, standardization, and technical research in the field of armaments."[1] The Board has had limited success in fulfilling its mandate. Today, some broad figures given the US Congress attempt to show that NATO combat effectiveness could be increased 30 to 40 percent were standardization achieved.[2] Dangling before the eyes of the US Congress is a potential annual saving of 52.6 billion, and more than a third of the annual NATO conventional force research and development (R&D) expenditures, should the bugaboos of "duplication" in weapons research and fierce commercial competition be eliminated.[3] But the politico-economic realities of the Allied coalition render those figures elusive, if not illusory, and, in all practicality put a high level of standardization out of reach.

Successes which approach standardization, such as with ROLAND, appear one case at a time. Militarily, presenting a substantially standardized NATO force to the Warsaw Pact is considered undesirable in many quarters, because it simplifies the Soviets' task of developing countervailing systems, doctrine, and tactics. An optimum level of standardization lies somewhere short of that, and has acquired its own terminology of rationalization and interoperability.

National Defense Industries

Some blame the pursuit of profit among the competing national defense industry establishments, which is to say the money side of the triangle of money, politics, and war, for the shortfall in achieved and achievable standardization. Arms deals and dealers evoke images of immoral profits in many minds. But the armaments industries of today's nation-states are no longer allowed to operate entirely by the rules of free competition as enunciated in the theories of Adam Smith. Arms makers are semicaptured at best—or at worst depending on the point of view—by their respective governments and are made to conform to the political morals and mores of each respective state.

In Europe, when the Treaty of Rome established the European Economic Community (EEC) to coalesce a European market, government procurement was specifically excluded. Consequently, defense industries remained protected from the free market forces which might have led to a standardized or rationalized NATO military force, through the working of normal market forces alone.[4] Government control, and government desire to preserve political prestige by the preservation of home-based military industry, demanded political and diplomatic action to sustain each nation's industry by sales or, failing that, by subsidy. By this curious duality, it is not the profit motive of capitalism in a free market system that militates against achieving weapons standardization within the Alliance, but the political inability to allocate internationally the division of available purchasing monies, hence profits.

Events Driving NATO Military Standardization

In the past several years many military, political, and economic events have impacted on the Western World in general, and on the NATO Alliance in particular, which have sharply raised the significance of pursuing some level of standardization in the military sphere.

Militarily, the Soviet Union has attained strategic nuclear parity with the United States, consequently decreasing the credibility of a US strategic nuclear response to a Soviet conventional attack on the European peninsula. The change in the strategic nuclear balance has shifted emphasis to NATO conventional forces and, concurrently, has renewed interest in improving conventional capability through standardization.

Economically, the demise of the Bretton Woods Agreement and the associated restructuring of the Western currency system—along with a severe realignment of currency flows due to oil price changes, inflation, demonetization, and devaluation—combined to transform radically the economics of NATO's defense strategy.

Politically, too, the divergent goals of the United States and the European members of the Alliance during Vietnam, the 1973 Mideast war, and the subsequent oil embargo, plus the limitations on European governments' freedom of action because of the rise in influence of leftist, and particularly Communist parties, called for new measures to reassert NATO's political cohesion and unity. Not the

least of the possible avenues toward resolving these fundamental issues are joint weaponization ventures.

Changes in US policy to reverse the shifting NATO/Warsaw Pact balance began to appear—with accelerating emphases in the years following the Vietnam war. The Carter administration, by initially excluding NATO from the restrictions on arms transfers announced in February 1978, and by more positive pronouncements subsequently, has reaffirmed, even reinforced, moves to assure the viability of the Alliance, thus continuing in the path taken by previous Democratic and Republican administrations.

European NATO leaders were quick to point out that consideration must be given to the significantly changed situation in arms manufacturing that has occurred since NATO was established, and to the new realities of US-European politico-economic relationships which have emerged in the last few years.

In the initial aftermath of World War II, NATO standardization meant, properly, to equip with surplus US weapons—the European industrial establishment had been exhausted by the war and rebuilding the civil sector took priority. Today the industrial base of NATO member states has quite changed—Germany, the United Kingdom, Italy, the Netherlands, and Belgium, not to mention France, possess not only a recovered civil industrial base but a significant military industrial capability. Yet, as a German white paper circulated to the US Senate pointed out, during the 1960's the United States sold $8 billion worth of military equipment to Europe and bought only $700 million in return.[5] These figures portray the magnitude of the Intra-NATO arms sales issue in the familiar terms of postwar recovery, with which most readers can identify intellectually. The figures, however, do not portray the more recent transformation in politico-economics among the Trilateral Powers (United States, Western Europe, and Japan) that has occurred in the last few years—a transformation that witnessed the United States, accustomed to ranking first or second in per capita gross national product, ranking fifth in 1975.

It should be clear that the notion of a "two-way street" in NATO arms procurement is not just the jargon of an arms sales drummer's brochure. Reasons which go beyond ideology and the accidents of history point to a "two-way street" as desirable, necessary, and inevitable. The seemingly predestined increase in multinational armaments production is simply a manifestation of the more

profound transformation that has occurred in Western politico-economics.

Congressional Initiatives

The US Senate has responded, and in many respects has taken the lead, to pave the way toward NATO standardization. Senators Culver and Nunn introduced an amendment to the DOD Appropriations Authorization Act of 1975 requiring the Department of Defense (DOD) to pursue NATO standardization actively. The Culver-Nunn amendment states in part:

> It is the sense of the Congress that equipment, procedures, ammunition, fuel, and other military impedimenta for land, air, and naval forces of the United States stationed in Europe under the terms of the North Atlantic Treaty should be standardized or made interoperable with that of other members of [NATO] to the maximum extent feasible.[6] (Sec. 814 (1) P.L. 94-106)

In fact, the original wording of the Senate bill declared it was "the policy of the United States that . . . ," but the wording was changed for fear of it being misconstrued.[7]

The *1976 and 1977 Department of Defense Appropriation* Acts would see realization of the original wording, making such feasible standardization a national policy. The later acts added:

> Whenever the Secretary of Defense determines that it is necessary in order to carry out the policy expressed in paragraph (1) of this subsection, to procure equipment manufactured outside the United States, he is authorized to determine, for the purposes of the [Buy American Act] that the acquisition of such equipment manufactured in the United States is inconsistent with the public interest.[8] (Sec. 814(a) DOD Appropriations Act, 1976)

The legislative action was implemented by a DOD memorandum signed by Secretary Schlesinger in November 1975, spelling out policy to be followed by the armed services, the Joint Chiefs of Staff, the Director of Defense Research and Engineering (DDR&E), the Defense System Acquisition Review Council (DSARC), and others, and establishing a DOD Steering Group on NATO Rationalization/Standardization.

As with many laws and regulations, these, too, ran afoul of other laws made at other times to solve other problems, such as the 1933 Buy American Act, joined by sections of the Armed Services Procurement Regulation (ASPR), concerning the Balance of Payments Program and specialty metals, various Executive Orders, and the US Code. For example, when the Army decided to purchase the Belgian MAG-58 armor machinegun instead of the Maine-produced M60E2, the Maine congressional delegation and the Maine-based manufacturer filed suit and obtained an injunction enjoining the Army from awarding the contract until the conflicting interpretations of the law could be resolved. A General Accounting Office (GAO) investigation found favorably for the Army and an amendment offered by William Cohen (Republican-Maine) to delete the $15.1 million appropriation for the machinegun was defeated by a standing vote in the House.[9]

United States politicians could point to only a scant few examples of action sustaining the words of acceptance in principle of the "two-way street." The US/German tank controversy, the fate of UK Harrier which seemed to be suffering the problems of an unsuccessful organ transplant, the Italian OTO Melara naval gun which, though successfully transferred, saw the US ammunition redesigned away from interoperable use, all seemed to be signs reading, ONE WAY. Particularly after the arms deal of the century with the F-16, US credibility in opening a "two-way street" fell to a low ebb. The players could only await events which would offer proof of the change of thrust in a new arms policy.

When the US Army decided to acquire a class of weapon such as ROLAND, it was clear that a European system would have national and international politics going for it.

CHAPTER I ENDNOTES

1. Congressional Research Service, *NATO Standardization: Political, Economic, and Military Issues for Congress*, 29 March 1977 (Washington, DC: Government Printing Office, 1977), p. 8.

2. Ibid., p. 1.

3. Thomas Callaghan, *US/European Economic Cooperation in Military and Civil Technology* (Washington, DC: Georgetown University Center for Strategic and International Studies, March 1976), p. 21.

4. Congressional Research Service, *NATO Standardization*, p. 10.

5. US, Congress, Senate, Committee on Armed Services, *European Defense Cooperation*, Hearings, 95th Cong., 2d sess., 31 March 1976 (Washington, DC: Government Printing Office, 1976), p. 149.

6. Congressional Research Service, *NATO Standardization*, p. 15.

7. Ibid.

8. Georgetown University Center for Strategic and International Studies, *Allied Partnership in Armaments, Transatlantic Seminar*, CSIS Report, Senator Sam Nunn and Representative Charles Bennett, Co-Chairmen (Washington DC: Georgetown University Center for Strategic and International Studies, 1977), p. 38.

9. Congressional Research Service, *NATO Standardization*, p. 23.

CHAPTER II

THE MILITARY REQUIREMENT

The requirement for mobile air defense weapons to accompany forward tactical elements has long been recognized on both sides of the Iron Curtain. However, fielding modern air defense systems was constrained by limited technology or limited money, or both.

Soviet Air Defense Requirements

According to Colonel-General P. G. Levchenko, Chief of the Soviet Air Defense Branch, the revolution in military affairs brought on by nuclear weapons

> . . . whose carrier was primarily aviation, sharply increased the role of air defense in combined arms warfare and in operations of the Ground Forces. . . . A principal new weapon was developed—the highly mobile AA missile complex of various types, and also AA self-propelled artillery mounts, new means of radar reconnaissance and apparatus for the automation of the system of control.[1]

For many years after World War II, major air defense in the Soviet Union consisted of a single organization, *Voiska Protivovozdushnoi Oboroni Strany* (Air Defense of the Nation, or simply PVO Strany), equipped with groundbased antiaircraft weapons and interceptor aircraft to counter the US Strategic Air Command. However, recognition of the different air defense requirements, and the weapons needed for combined arms formations in the field, led In 1958 to formation of a separate branch within the army itself, *PVO Sukhoputnikh Voisk,* (PVO of the Ground Forces, or PVO SV). PVO Strany today remains a separate service, charged with air defense of the Soviet homeland, on a par with the Army, Navy, and Strategic Rocket Troops. PVO SV provides air defense to the army in the field, and is a separate combat arm within the army similar to armor, artillery, or motorized rifle forces.

Establishment of a separate PVO SV led to expansion of that specialty's training base from small faculties at the Military Artillery Academy F. E. Dzherzhinsky and the Military Academy M. V. Frunze, both prestigious in their own right, to branches at the Military-Artillery Academy M. I. Kalinin and at five higher military schools.[2] According to a 1977 article in the Soviet Army newspaper, *Krasnaya*

Zvezda, the Kiev branch of the Kalinin Academy has since become a separate PVO SV academy.[3]

Soviet tactical doctrine influenced the design of technical means with which to arm the new PVO SV branch. In 1970, Colonel A. A. Sidorenko, then a Candidate of Military Science, published a book, *Nastupleniye* (The Offensive), describing the combined arms tactics the Soviets envisioned for use in a war with NATO. Nuclear weapons would provide the main means of waging war. Widely separated, fast-moving masses of tanks and infantry carriers, bypassing regions of destruction, floods, and fires, would race up to 100 kilometers per day to exploit the gaps, overrun devastated units, and seize key objectives deep in NATO territory. All else would be subordinated to exploiting the confusion of the gigantic battlefield and maintaining the tempo of the attack.[4] However, without adequate means of accompanying air defense, the armored formations Sidorenko described would be especially subject to defeat in detail by NATO air strikes.

Sidorenko's landmark publication undoubtedly reflects tactical thinking developed much earlier in classified circles. At publication, only the ZSU 23-4 self-propelled, 4,000 rounds per minute, radar-directed gun, displayed in 1965, and the two-vehicle SA-6 Gainful missile system, paraded on Red Square in 1967, were in the field. But, within 3 years, the SA-6 and ZSU-23-4 in the Mideast provided the world its first example of mechanized warfare waged with the added dimension of these new kinds of air defense weapons, reversing the advantage gained by Israeli aircraft over Egyptian armor in 1967. The track-mounted ZSU-23-4 Shilka radar-directed AA gun tank moved right along with lead elements of the armored formations. Shilka accounted for at least one-third of Israeli aircraft losses. The SA-6 Gainful missile system, employing radio links between tracked launch vehicle and track-mounted Straight Flush radar control vehicle, perhaps surrenders some of the accuracies of a cable interconnection such as is used with US HAWK, but achieves the mobility and fast reaction Soviet tactics demand and Arabic forces employed.

More recently, in the Soviet Union, the mobile SA-8 and SA-9 missile systems were publicly displayed and an improved version of the shoulder- fired SA-7 Strela was mounted in a multiple launcher on a mobile armored carrier.[5] The SA-8 Gecko, paraded in 1975, despite its seemingly large size and "made in Minsk" look, has, like ROLAND, achieved the high mobility and fast reaction afforded by mounting

missiles and fire control on a single vehicle. The SA-8 is amphibious, too.[6]

In an article in the 1976 *Soviet Military Encyclopedia*, Colonel-General Levchenko, PVO SV Commander, summarized the military characteristics his branch's air defense systems should have:[7]

—High mobility

—All-weather capability

—Automatic processes for detection, identification, and hitting the target

—Minimum time to get into readiness to conduct fire

—The capability to destroy targets executing low altitude flight paths.

The Soviet weapons paraded on Red Square certainly displayed the characteristics General Levchenko specified and provided Soviet PVO SV the weaponry in breadth, depth, and variety to carry out its assigned role in *The Offensive.*

Western Air Defense Requirements

In West European armies, there was also a recognition of the vulnerability of armored formations to attack by sophisticated aircraft. Colonel Charles Ott of the Swiss Army, writing in *the Allgemeine Schweizerische Militarzeitschrift* in 1972, noted:

> All reports on maneuvers in the West or the East show that at present and in the near future no ground operations without direct air support are taking place or are likely to take place. The destruction of tanks from the air remains the most economical and safest way. Experience from the "Six Day War" and from NATO exercises allocate from 60 percent to 70 percent of all destroyed tanks to aircraft and helicopters.

Addressing the solution for his own army, Colonel Ott described the differing roles played by antiaircraft tanks with fast-firing, radar-directed guns for low altitudes; by missiles for medium to high altitudes; and by weapons for the intervening altitudes:

Thanks to considerable competition, a whole string of suitable products are maturing in Western Europe, as for example, CROTALE (France), RAPIER (UK), INDIGO (Italy), ROLAND (France/Germany).[8]

Colonel Ott's article was particularly significant in implying that such missiles could serve as replacements for Switzerland's then aging interceptor force. Seldom in the evolution of military technology do such radical advances in capabilities occur to warrant exchanging one class of weapon for an entirely different class—even in a limited situation such as that of Switzerland. To date, several European armies have begun deploying some of the systems Colonel Ott described.

Combat Developments—US/USSR

In the United States, the US Army recognized the need for such weapon systems quite early, perhaps too early. In the mid-1950's, General Dynamics Corporation was hard at work developing the innovative infrared-seeking, man-portable REDEYE antiaircraft missile. Infrared guidance technology was coming to the fore and several laboratory attempts were made to extend the technology to larger, all-weather, vehicular-launched systems, but without success. The US Army, with General Dynamics as prime contractor, decided instead to design a radar-guided missile system, the MAULER, packaged aboard a single vehicle. MAULER proved too ambitious for the scientists and engineers on the one hand, and too subject to a continuous extension of desired performance specifications called "requirements growth" on the other; these problems were compounded by long delays which allowed successive changes of personnel to move through the managing governmental organizations. As the war in Vietnam began to consume a larger share of the DOD budget, MAULER's too ambitious technology and too burdensome costs brought about its demise. In 1965, after 8 years and $250 million, MAULER was terminated.[9] But how does a bureaucracy terminate a "project" which acquires its own momentum and whose engineers continue work as long as an eventual contract is in sight?

Within the US military weapons acquisition establishments, rigorous, documented procedures are prescribed for acquiring weapons, which begin with definitions of tactical or doctrinal objectives. The studies, analyses, and field experiments which lead to these formal definitions are termed "combat developments" by the US Army.[10] This activity parallels effort in the technical laboratories

which attempts to blend new tactics and new technology. The formal definitions of desired properties, and functioning, of a proposed weapon are recorded in a series of "requirements documents" prepared at key decision points in the weapons/tactics evolutionary process. When performance capability and developmental risk are believed sufficiently clear, budgeting and programming procedures are defined in other rigorously drawn documents, and contracting for the end item begins.

In the Soviet case, these combat development efforts seem to be placed with the schools and academies, especially those possessing internal research elements, that work in concert with appropriate elements of the Ministry of Defense Industry. Although we are not privy to the details, which are Soviet state secrets, the following is generally known relative to Soviet new weapons projects: Once agreed upon by the Communist Party hierarchy which parallels in organization the military and civilian governmental establishments, new weapons projects are assigned to appropriate Design Bureaus—sometimes to several in the interests of "Socialist Competition"—where prototype development begins.

In the United States, combat development activities tend to be centralized in organizations such as the Army's Training and Doctrine Command (TRADOC), with the schools of each branch of service closely intertwined by formal and informal arrangements, as is the Army's centralized Materiel Development and Readiness Command (DARCOM) during the earlier concept formulation phases. How a concept moves to definitive hardware procurement and how primary responsibilities shift from organization to organization is presented in a number of specialized and detailed documents—beginning with DOD Directive 5000.1 and Office of Management and Budget Circular A-109, followed by Army Regulation 1000-1 and numerous regulations and implementing memoranda. The procedures comprise a study in themselves.

In MAULER's case, the all-weather system requirement had made its way to a document called the Combat Developments Objective Guide, which served as the Army's authorization document to obtain and spend money for exploratory development. To terminate MAULER, the US Army arbitrarily, and somewhat disingenuously, deleted the all-weather requirement from the official requirements document. The action provided a bureaucratic signal similar to the Federal Reserve raising the discount rate in that it bore little causality but did put "the project" on notice that no more money

would be forthcoming for that genre of weapon. Needing at least some kind of air defense as a quick fix, the Army deployed the Philco-Ford CHAPARRAL, adapted from the heat-seeking SIDEWINDER, as a clear-weather-only interim system.

While the Soviet Union continued building its inventories of SA-6 and the US Army became preoccupied with Vietnam, the all-weather mobile surface-to-air missile (SAM) requirement was not entirely ignored by the United States or NATO. In the United States, the Army in 1970 compiled the Air Defense Evaluation Study, ADE-80, which reaffirmed, for the 1980's, the need to improve the short-range CHAPARRAL type of weaponry, though the study circumvented the all-weather specification.

In Europe, in 1964 and 1968 respectively, work was begun to develop all-weather CROTALE and ROLAND II, the latter project to extend the clear-weather capabilities of ROLAND I to meet the perceived all-weather (or almost all-weather) threat.

Counterpart Soviet SAM's are not, of course, the reason the United States or NATO should develop such weapons, which simply reflect similar responses of different armies to tactical requirements. Rather, the true basis for such weapon development is the threat posed by the capabilities and numbers of advanced Soviet aircraft. Specifically, air defense weapons like ROLAND must overcome the strike aircraft of the Soviet Air Force Frontal Aviation Arm (FA), in all probability reinforced by medium bombers of Long Range Aviation (DA), that present the main aircraft threat to NATO ground forces and installations.

Soviet Frontal Aviation

The Soviet Air Force Frontal Aviation Arm takes its name from the fact that it is subordinated to the ground forces "Front" comprising several armies—Tank or Combined Arms Armies and an Air Army (VA). Should war occur, each Military District in the USSR and each Group of Soviet Forces in Warsaw Pact states would probably form a Front.[11] The largest army of Frontal Aviation is the 16th VA, with 1,100 aircraft, supporting the Group of Soviet Forces Germany (GSFG).[12] The threat posed by aircraft deployed in the other Groups of Forces and Military Districts in the European USSR (totaling 2,725 aircraft)[13] certainly cannot be ignored. Backfire, on two-way missions, can cover the whole of Western Europe flying low-ingress, low-attack, low-egress from as far back as Lvov in the

Ukraine.[14] The new Sukhoi-designed Fencer A, even when launched from its first deployment base as far back as Kaliningrad on the Baltic, can reach southern Norway, Sweden, West Germany, the Netherlands, and Austria, all while flying at altitudes below NATO's NADGE[15] early radar detection.[16]

During the mid-1970's, a marked qualitative and quantitative improvement has occurred in Frontal Aviation. FA is charged with air defense of the Front and with close support and interdiction. But within the Front, much of the air defense role has been taken over by the surface-to-air missiles and guns of PVO SV. In this regard, Sidorenko notes, variously, in *Nastupleniye:*

> The means of troop air defense have now become qualitatively different. Their basis is the antiaircraft missile and artillery complexes. . . .[17]
>
> Aviation should be used to launch strikes . . . outside the zone of effective fire of our antiaircraft weapons. . . .[18]
>
> The most important is the destruction of the enemy's means of nuclear attack.[19]

Qualitatively, while Soviet PVO SV helps *release* Frontal Aviation for a gigantic air/SAM battle which would likely occur, recent studies have shown FA holdings themselves have increased

> . . . by 30 percent since 1969 and the overwhelming majority of tactical aircraft types currently in production are optimized for ground attack rather than air superiority missions. The new Fencer A (Sukhoi 19), Flogger D (MIG 27),[20] and Fitter C (Sukhoi 17),[21] in that order of importance, give Soviet FA a low level interdiction capability that previously was missing.

Top of the line Fencer A (Sukhoi 19) is the first Soviet aircraft since World War II specifically designed for ground attack. The two-seat, apparently two-engine, craft can reach all NATO targets within the European theater. With terrain avoidance radar and laser rangefinder, "Fencer A, flying a low altitude ingress, attack, and egress mode poses a novel threat to NATO. Between 200 and 250 Fencer A's are now in service with Frontal Aviation in Europe."[23]

Frontal Aviation also owns and operates the Mi 24 (Hind) helicopters. Hind added a new facet to FA capability, beginning with the 1974 deployment of at least two squadron-strength units to

GSFG. Presently, full regiments of Mi 24 Hind are stationed at Parchim and Stendal, northwest and west of Berlin respectively, along the West German border. Hind A carries an eight-man assault squad, a crew of four, a large caliber nose-mounted machinegun, and three heavy-armament weapon stations. Hind D, primarily a gunship, is redesigned to afford tandem stations for pilot and weapons operators, and to accommodate a chin-mounted four-barrel Gatling-type gun, the same 57mm air-to-surface rocket pods as the Hind A troop carrier, and other heavier armament. The chin pod of Hind D also mounts what appear to be a forward-looking infrared scanner and low-light level TV.[24] Soviet helicopters are known to employ antitank missiles in their assault role.

While Soviet airpower played a limited role in World War II, as compared to the role of Soviet land forces and the role of other nations' airpower, current Soviet airpower has been developed to quite an advanced level. However, the experience of the United States in gaining air superiority in three wars provided little impetus for spending limited funds for close-in air defense.

US Air Defense Developments

Organizationally, US antiaircraft artillery remained part of the Coast Artillery Branch until 1950. Only in 1958 was it officially recognized by the addition of a missile to the crossed cannon insignia of the Field Artillery Branch. Only in December of 1968 did it become a separate branch of service, just in time to deploy CHAPARRAL and its complementing gun, VULCAN.

Since parting with the Coast Artillery faculty in 1942, the US Army's Air Defense Artillery had had its own school and faculty at Fort Bliss as a subordinate branch of the Artillery School. However, the Commandant, the only flag officer, was headquartered at the Artillery School at Fort Sill until 1955, when the Air Defense School became a separate entity.[25]

In 1969, the year following establishment of the US Air Defense Artillery, the Army began to seek weapons to round out the low-altitude end of the scimitar of ABM, NIKE, and HAWK with which to equip the new branch. The US Army Missile Command at Redstone Arsenal circulated a Request for Proposal (RFP) for a new Low Altitude Field Army Air Defense System (LOFAADS) concept. Three corporations—General Dynamics, Hughes Aircraft, and Raytheon—were funded for in-depth proposals. All of them suggested a

sunshine-belt-only solution, with modular upgrading to all-weather. The 1970 proposals estimated 11 years would be required for research and development of the new systems.

In other combat development activity in April of 1971, as a follow-on to the ADE-80 study, the US Army chartered the Field Army Air Defense Study (FAADS) group. This group reported back a requirement to replace CHAPARRAL at an estimated price tag of $5 billion. The reaction was negative! The Department of the Army declared the study "inconclusive."

The United States looked at the growing Soviet threat and the further advanced European CROTALE, RAPIER, and ROLAND. The politics and the technology were in harmony. As the Vietnam involvement concluded, the money became available. Establishing Air Defense Artillery as a branch in its own right provided the institutional impetus. Money, politics, and war had set the stage for ROLAND.

CHAPTER II ENDNOTES

1. MSU Grechko, Chairman of Editorial Commission, *Sovyetskaya Voyenaya Entsiklopediya*, vol. 1 (Moskva: Voyenizdat, 1976) p. 25.

2. Ibid., p. 322ff.

3. *Krasnaya Zvezda*, Moscow, 23 September 1977, p. 3.

4. Colonel A. A. Sidorenko, *Nastupleniye* (Moskva: Voyenizdat, 1970).

5. Colonel D. Malone, "Air Defense of Soviet Ground Forces," *Air Force Magazine*, Soviet Aerospace Almanac edition, March 1978, p. 79.

6. Ibid., p. 79.

7. Colonel-General Levchenko, "Voiska PVO SV," In *Sovyetskaya Voyenaya Entsiklopediya*, vol. 1, p. 322ff.

8. Colonel Charles Ott, "Schutz Unserer Mechanisierten Verbande—Steigende Bedrohung Aus der Luft," *Allgemeine Schweizerische Militarzeitschrift*, April 1972, p. 179ff.

9. US ROLAND Project Office Historical Report, 1 December 1976, US ROLAND Project Office, Redstone Arsenal, Alabama, p. 2.

10. Combat Developments - "A major component of force development which encompasses the formulation of concepts, doctrine, organization, and materiel objectives and requirements for the employment of United States Army forces in a theater of operations or in the control of civil disturbances. It includes development of Army functional systems (logistics, personnel, administrative, and other as designated) which impact directly on or extend into a theater of operations." Army Regulation 310-25, *Dictionary of United States Army Terms* (Washington, DC: Headquarters, Department of the Army, 15 September 1975) p. 65.

11. Willlam F. Scott, "Troops of National Air Defense," *Air Force Magazine*, March 1978, p. 57, quoting *Military Balance*, ISS.

12. Colin Gray, "Soviet Tactical Airpower," *Air Force Magazine*, March 1977, p. 62.

13. Ibid., p. 63.

14. D. Boyle and R. D. M. Furlong, NATO AWACS, "Now or Never?" *International Defense Review* 10 (February 1977): 43.

15. NADGE: NATO Air Defense Ground Environment, a network of radars, and command and control facilities.

16. Boyle and Furlong, "Now or Never?" p. 43.

17. Sidorenko, *Nastupleniye*, p. 47.

18. Ibid., p. 48.

19. Ibid., p. 129.

20. Flogger D (MiG 27) is a single-seat ground-attack variant of the MiG 23 fighter. The MIG 23, first delivered to Frontal Aviation in 1971 and whose later variant appeared in GSFG squadrons in 1973, will likely become the mainstay FA standard combat aircraft, with some 850 of all types presently active. Its electronic equipment and armament (GSh 23mm twin-barrel gun plus air-to-air missiles) indicate an intercept role within FA, but a laser rangefinder and other accoutrements indicate a multirole capability. One Flogger C variant

is noted to be an ECM version. (George Panyalev, "The MiG 23 Flogger," *International Defense Review* 10 (February 1977): 48ff.) Flogger D, the ground-attack variant, appears to have a more powerful engine with fixed nozzle and air intakes consistent with high subsonic speed at low altitudes. Additional armor is provided on the sides and a laser rangefinder and marked-target seeker are incorporated into the redesigned forward fuselage. Flogger D exchanges the 23mm GSh machinegun for a 30mm, 6-barrel Gatling-type gun and has provisions for air-to-surface missiles and active ECM. (John W. Taylor, "Gallery of Soviet Aerospace Weapons" in *Air Force Magazine*, March 1978, p. 98.)

21. Fitter C, first shown at the Domededovo Air Show in 1967, is an uprated mach 2.17 variable geometry version of the Sukhoi 7, Several hundred are presently deployed, including the ground attack regiment at Finsterwalde, East Germany, (John W. P. Taylor, "Gallery of Soviet Aerospace Weapons," *Air Force Magazine*, March 1978, p. 93ff.) and 10 squadrons in the Polish Air Force. (Gray, "Soviet Tactical Airpower," p. 63). Payload/armament includes two 30mm machineguns, 11,000 pounds of bombs, rocket pods, and AS-7 air-to-surface guided missiles. Fitter D apparently sports an undernose radome and laser-marked target seeker. (John W. Taylor "Gallery of Soviet Aerospace Weapons," *Air Force Magazine*, March 1978, p. 93ff.)

22. Gray, "Soviet Tactical Airpower," p. 63.

23. Ibid.

24. Taylor, "Gallery of Soviet Aerospace Weapons," p. 93ff.

25. Information courtesy of Mr. James Lemmons, Historian, US Army Air Defense Artillery School, Fort Bliss, Texas.

CHAPTER III

ESTABLISHING THE RULES

Legislation by the Congress and implementing memoranda by DOD to encourage NATO standardization were noted in chapter 1. But the general term "standardization" must be applied in a more finely tuned world to take effect. Three terms comprise the NATO jargon:

> ***Rationalization* is the "umbrella term" used to describe any action which makes more rational use of our defense resources both as individual nations and collectively. This includes a better and more efficient division of tasks or at least compatibility of equipment among allied forces.**
>
> **We use *standardization* to cover the adoption of common equipment, doctrine, and procedures among various members of the Alliance. This is the most difficult element of rationalization to achieve, and the most misunderstood concept. Essentially standardization is a long-term undertaking. It starts with coordinated research and development, and a common perception of the future threat together with an agreed approach as to how to deal with it.**
>
> **The term *interoperability* is used to describe those steps taken to make different equipment more compatible. This includes interchangeable parts and consumables, such as fuel and ammunition, and the ability to cross-service between forces.[1]**

There are also three approaches to acquiring standard items for NATO, each of which entertains its own strengths and weaknesses, and each of which must be understood to appreciate the relative plusses and minuses of ROLAND's approach:

> *Direct purchase* of an ally's weapons system permits the purchasing state to avoid the R. & D. costs of developing a similar system and the expense of establishing a domestic production base. Production under a single manager can result in longer production runs, thus achieving a more efficient economy of scale, and it insures equipment standardization between buyer and seller. The limitations of this approach are negative balance of payments effects (unless offset by other military or nonmilitary trade), domestic employment losses, and the risks of relying on a foreign country for logistics support. Whether this approach will be applied more widely on a trans-Atlantic basis will depend on whether the governments can compensate for these drawbacks

and upon their willingness to look beyond the individual project level and establish a broader framework that balances purchases with sales (the "two-way street").

Competitive R. & D. with licensed coproduction is the approach to standardization currently favored by the Defense Department. Legislation passed by Congress in 1976 endorsed this approach and expressed the sense of the Congress that coproduction would minimize the potential economic hardships of standardization (particularly the loss of domestic employment) and increase the survivability of the Alliance's production base in time of war. The coproduction approach achieves most military advantages of equipment commonality. Nevertheless, if the competitive R. & D./coproduction approach is the preferred US option for tackling standardization, then it is not realistic to estimate cost savings in the range of $10-$15 billion annually. Even were it assumed that the estimate is accurate, it is predicated upon a total elimination of all duplicative R. & D. and production and a complete rationalization of allied logistics. The coproduction approach does not purport to incorporate these reforms. In fact, the evidence indicates that coproduction may lead to higher costs and suboptimal economies of scale. These inefficiencies may, in turn, increase pressures for non-NATO exports.

Cooperative R. & D., with two or more states teaming up to design common equipment from scratch, is being employed extensively in current Euorpean joint ventures. However, this approach has been somewhat discredited in the United States by some bad experiences in the past, most notably the abortive MBT-70 tank program. It might have a brighter future on a trans-Atlantic basis once there is a broader consensus on the need for standardization, closer harmonization of military requirements and doctrine, and greater integration of European armaments industry.[2]

ROLAND most closely followed the third approach insofar as Germany and France are concerned, and the second insofar as the United States is concerned. But "closely" is all that can be said. No single example of a complex weapon is going to fit into such neat packages. Although the DOD "favored," and the Congress endorsed, competitive R&D followed by licensed coproduction, conflicts of ends and means entered quickly into play. The notion of competitive R&D and licensed coproduction is clear enough, but selecting policies and procedures to form the bridge from international competition of R&D to the production phase in the United States was, and remains, highly controversial. The abutments upon which the

bridge is laid are licensing—when and by whom—and source selection by the armed service involved—on what basis and in what manner.

The Source Selection Abutment

Because of the strong role played by the Army's Combat Development Command or its successor, the Training and Doctrine Command, in this country's Army, procurement agencies have grown accustomed to specifying a single requirement to several companies. The agencies then evaluate the responses for the identical system description or required operational capability on the basis of competitive price, cost effectiveness, or military effectiveness.

Many adherents of this procedure believe it should be extended to the international arena as well. Several advocates of this approach remarked, "Such a competition is the only way to get the best or even a decent price." Opponents argue that people support the approach because "that's the way it's always been done" or allege that it is just a mind set that "follows Ordnance Corps tradition" which does not fit the current realities of Rationalization, Standardization, and Interoperability, or the expanded international marketplace that now exists. The two appositive positions were expressed in interviews by senior military officers and corporate executives respectively.

The nature of the current international marketplace and fundamental differences in US and European military industrial relationships dictate to a degree which courses of action can be made operable. The West European military industrial establishment does not normally follow the rigid combat developments process familiar to the United States. Rather, industry develops, and to a large extent maintains and supports, systems it thinks the military needs and, hence, will purchase. Europeans working with ROLAND and exposed to US combat development and project development methodologies expressed a degree of awe at both the US system's efficacy in securing high performance weapons and its expense just to pay the salaries of all the people involved.

Three candidate systems from different European national and international corporations competed in the ROLAND selection process. The competing systems provide a clear example of the differing threats and differing requirements which different countries, armies, and corporations perceived and expressed in the design philosophy of their candidate weapons. United Kingdom RAPIER

offered a clear-weather system optimized to optical guidance which was eventually to be upgraded to all-weather, multivehicle BLINDFIRE. French CROTALE presented a multivehicle, high-performance system designed from the start as all-weather. Euromissile ROLAND II proffered the single vehicle all-weather approach, perhaps surrendering some of CROTALE's high-performance qualities, but focusing on the need to match the mobility of armored or mechanized formations with a self-contained vehicular mounted system. Clearly, selecting from among such divergent solutions would not offer a simple cost-based competition.

In the traditional pattern of US Army procurement, the Source Selection Board would select a producer based on costs and effectiveness to match a single concept measured against a single yardstick. In an evaluation such as with ROLAND, the Source Selection Board would have to evaluate different systems developed to meet different operational requirements, even different threats. Does the latter constitute competition? Some will argue yes, and some will argue no.

The second approach does offer a broader competition of ideas, with attendant relative cost effectiveness; the arena of competition of ideas is extended beyond the familiar one embracing research and development processes to one wherein entire societal processes for developing weapons and tactical doctrine as perfected by the corporations and military establishments concerned, are placed in competition. Whether that constitutes competition, or whether the added complexity of Source Selection in such a broad context is worth the price, may lie in the eyes of the beholder. Whether such a comprehensive approach is preferable to the monolithic approaches that gestated the MAULER, which proved premature, or the SA-6, which also proved somewhat limited, is arguable.

The Licensing Abutments

Hughes, eventual winner of the US competition, prepared a white paper of lessons learned which discussed various ways to build the other abutment of the bridge between competitive R&D and licensed coproduction, which is to say the license itself. One way results in approximating the traditional source selection approach; the other way departs from it:

> One possibility was for the US DOD to negotiate for and procure the license from European industry. The military service

involved could then conduct a competition within US industry for this [one] weapon system. Such a process would have the advantage that a competition could be held with US industry bidding on the same system. This would require, of course, that the DOD evaluate beforehand the foreign systems in order to determine which one to license and thereby which one to compete. Such an evaluation would have to include an assessment of the price, reliability, reproducibility, mission suitability, and delivery schedules for each system considered. Each such assesment would be based on the assumption of procurement from a member of US industry not yet identified.

A major disadvantage would be that the problems of negotiating a license between the US Government and a foreign company would become very difficult. The reason for this is that the US Government must provide technical data on the foreign system to all potential US competitors. However, foreign industry wishes to avoid wide dissemination of its technology; therefore, the US Government is faced with a very difficult license negotiation task in order to allow this. It is theoretically possible to obtain the freedom for the wide dissemination of data, but foreign industry would require the payment of very much higher fees for the transfer of data under these conditions thereby adding an inordinate increased cost to the program. Another disadvantage is that the contractor can claim that any significant problems arising during the technology transfer process are the result of a deficient data package supplied by the US Government. This would be in contrast to the contractor having to solve such problems with his licensor.[3]

Although white papers are supposedly written as objective studies, any such analyses prepared by contenders on one side or the other of an issue must be treated with a certain amount of skepticism. Nevertheless, in this writer's opinion, the Hughes paper actually *understates* the case rather than the reverse. If the US Government were to negotiate for a European weapon system of the magnitude of ROLAND, there would in all probability be government-to-government negotiations, as later actually occurred, not DOD-to-European-contractor negotiations, adding layers, time, and costs which the Hughes white paper omitted. Moreover, the evaluation process and licensing negotiations which would be needed to put the US Government in a position to issue an adequate Request for Proposal would demand a complex technology transfer in itself to accumulate the necessary detail of a supportive Technical Data Package. Also, the continued Reductions in Force that have occurred within the Army materiel management agencies, particularly within the laboratories, weigh heavily against a capability to support such an

undertaking. Although a less than complete Technical Data Package might suffice to support a bid, as the white paper indicates, its use would exacerbate the problem of laying the blame on the government for future difficulties which might occur from lack of specificity. The Hughes paper also discussed the other licensing approach

> . . . which appears to be the only feasible one. . . . That is, the US Government conducts a competition among similar systems which have been licensed by industry from the European developers. The advantage is that the European companies can select the US company which they feel can best represent their product. This approach has the further benefit that before the RFP is issued, the US company will put a great deal of resources into understanding his licensed system. This is done with the full cooperation of the licensor. Such cooperation would probably not be given to a multiplicity of competitive bidders if the US Government held the license.[4]

As opposed to understating the case for the procedure wherein the government arranges the license, the paper here seems to overstate the case. The argument that a European contractor would be much more cooperative in releasing data to a US corporate licensee than to the US Government, and that a US company would put a great deal of resources into understanding the system prior to winning a definitive contract, has not been borne out by events. The European companies in the competition, Euromissile no more or less, apparently, than the others, provided only enough data to support their licensees in making the initial bid.

Why would European companies be reluctant to release information about a system they would hope to sell in the large US market? Discussion with US and European representatives follows this line of reasoning: Euromissile sought the involvement of US dollars in ROLAND II. In fact, the entry of the United States provided a financial transfusion the system needed to realize a ROLAND II. But, Euromissile also feared a springboard effect with Yankee ingenuity. What if a winning or losing company developed a much improved weapon extrapolating from technology developed by Euromissile but given freely to support the US Source Selection? It is easier to design a much improved system when all the early technological problems are solved. Besides, areas where European companies enjoy marketable technological leads over the United States are not abundant. European firms were concerned the United States would reenter not only the European, but also the Third World, market with a sure winner built on European technology. Because it was in the

firms' best interests, Euromissile, prior to contract award, did provide complete drawings for one electronic and one mechanical subsystem to test the feasibility of building ROLAND in the United States using metric measurements and European prints.[5] The discipline imposed by money in our society works in many helpful ways.

The Project Manager considered the level of effort expended by Hughes in the embryonic stages of the project to be inadequate, particularly considering the multicentric managerial structure employed by Hughes Aircraft Company. These claims, too, are arguable. Hughes expended 300 man weeks and made 150 trips to Europe during the 5 years from 1970 to the date of contract award.[6] One must ask, how more such activity could have been financed by the firm? Overdoing on the opposite end, spending excessively to insure mastery, would invite allegations of "buying in."

The Government, too, it was believed, placed insufficient manpower into the early phases of the ROLAND program, for a variety of good and bad reasons. Despite being pointed out in "lessons learned" in both the excellent Hughes document and a parallel and equally excellent Department of Army "lessons learned" document it is doubtful if such early personnel problems are solvable. Experience has repeatedly shown that there are never enough resources to manage all the work going on in any given military procurement organization. Consequently, new projects must achieve a certain momentum before commanding sustained attention. It is only in major efforts which attract enough national priority to deserve the luxuries of bankrolled Contract Definition or Concept Development that something better can be expected.

It should be noted that the problems associated with the limitations on the transfer of data and the limitations on the level of early management effort to assess the European systems resulted in both government and corporate personnel erring in two crucial estimates. These misestimates—underestimating the difficulties of the technology transfer and overestimating the maturity of the Euromissile ROLAND II—seem to underlie all of ROLAND's subsequent problems.

A comparison of the two licensing approaches indicates that a policy whereby the US Government acquires the license, then competes a single weapons concept, would force the government developmental agency to manload sufficiently to avoid errors in estimation. However, current manpower policies indicate that

sufficient personnel to accommodate such a workload would not be possible. A policy of corporate-to-corporate licensing to form competing US-connected teams is a more facile approach, though it throws the load to the Source Selection process. But there is every reason to believe that it will not satisfactorily put to bed the problems of limited data exchange and limited preaward unfunded project effort. In either case licensing, because it occurs first, determines the nature of the competition in the Source Selection process; that is, one system concept or several.

Choosing a Bet

Judging the best practical approach, Deputy Secretary of Defense David Packard resolved the issue as it eventually applied to ROLAND with a memorandum to the Secretaries of the Army, Navy, and Air Force, *inter alia*, in November of 1971:

> Therefore, as a policy guideline, DOD procurement practices should not operate to discourage or inhibit US industry from forming working relationships with foreign industrial concerns relative to the import of foreign weapons system technology. The role of the DOD should be limited to evaluation of the competence of the US foreign industrial team and the cost effectiveness of its product in relationship to competing industrial teams and their products.[7]

Subsequent research has pointed to the Director of Defense Research and Engineering (DDR&E) as the proponent of this memorandum. Setting these rules, as will be seen, inadvertently or otherwise caused certain aspects of the ROLAND development to be cast in brass, which ultimately proved sharply contrary to the objectives of other elements of the military developmental bureaucracies.

CHAPTER III ENDNOTES

1. US, Congress, Senate, Committee on Armed Services, *European Defense Cooperation*, Hearing, 94th Cong., 2d sess., 31 March 1976 (Washington, DC: Government Printing Office, 1976), p. 36.

2. US, Congress, Committee on International Relations, *Standardization: Political, Economic, and Military Issues for Congress, Congressional Research Service Report*, 29 March 1977 (Washington, DC: Government Printing Office, 1977), p. 5.

3. Hughes Aircraft Company, "Lessons Learned on ROLAND, A Technology Transfer Program," white paper authored by Mr. Warren Currie, 30 March 1976, unpublished, pp. 4, 5.

4. Ibid., p. 5.

5. Ibid., p. 17.

6. Ibid., p. 3.

7. US, Department of Defense, Deputy Secretary of Defense Memorandum, 1 November 1971.

CHAPTER IV

ASSEMBLING THE TEAM

The Packard memorandum having established the rules, a variety of US and European groups began marshalling forces to promote their particular roles in the "weaponization process." Additionally, during the period 1970 to 1973, the Army undertook a series of doctrinal and theoretical studies to reexamine air defense requirements—especially the all-weather aspect of those requirements. The studies generally followed the Air Defense Environment ADE-80 study which identified the need to explore the low altitude end of the air defense spectrum.

The All-Weather Requirement

In 1970, disappointing response by industry to the Low Altitude Field Army Air Defense Study (LOFAADS) Request for Proposal led to the Field Army Air Defense Study (FAADS), chartered by Headquarters. Department of the Army in April 1971, which confirmed an all-weather requirement. However, the FAADS recommendation for satisfying that requirement proved to be too expensive (US $5 billion) and the study team was told to develop a less costly proposal. Subsequently, FAADS Phase II returned with a quibble to say there was no all-weather requirement. The Department of the Army would not approve the FAADS Phase II findings because the threat analyses did not support such conclusions.[1] The all-weather requirement, so easily deleted to terminate MAULER, was difficult to reinstate.

As occurs with all weapons development projects at this stage, the rather large, and with ROLAND, international, subculture of operations researchers entered the arena of combat development studies, in both government and corporate circles. This group had to evaluate the threat. Does or does not Frontal Aviation in the Soviet array of forces possess an all-weather (or most-weather) strike capability? Can they or can they not bring it to bear? Where? In what form would raids occur? What is the nature and effect of Electronic Countermeasures (ECM)? What are the technical and tactical properties of proposed friendly systems? The answers to these questions determine what form and what rules of engagement computer simulation models playing the adversaries will take; the simulation models then compare proposed systems by iterative simulations. The precise structuring of these simulations is critical,

because even though Operations Research/Systems Analysis (OR/SA) speaks with the seeming wisdom of mathematical authority, the system which looks best can be stacked as easily as words can be smithed.

Because FAADS addressed an international competition, the threat assessments of each nation's intelligence organization, as well as the threat estimations of the corporations within each nation, became involved in the OR/SA studies. It would be convenient, as the Hughes white paper had pointed out, to begin with an agreed upon threat, hence, a standard measuring rod in the front-end simulation studies. But such simplicity was not to be the case. Intelligence establishments, like other organizations, are influenced by politicization, bureaucratization, and the personal choice of intelligence analysts—all factors affecting the intelligence reported, disseminated, and "approved."

In the ROLAND case, an excellent, though very quiet, achievement along the road toward standardization occurred in the exchange of simulation models among the NATO SHAPE Centre Technique at the Hague, MICOM at Redstone Arsenal, and the TRADOC element at Fort Bliss. The SHAPE model, COMO, especially supplements the Air Defense School's model, TACOS, in El Paso. The two models, TACOS and COMO, served to support complementary analyses of the ROLAND system. TACOS presents an air defense battle in the operational sense, applying generalized algorithms of engagement representing missiles and aircraft. TACOS employs digital terrain and can play air-to-ground or ground-to-air engagements. COMO, on the other hand, provides a framework upon which to superimpose more technically detailed weapon descriptions. COMO employs statistical terrain replication rather than a digitized terrain model and handles more of the nuance of Electronic Countermeasures.

Operational research methodologies are particularly useful in air defense analyses because the equation of victory simply defines what runs out first—missiles, gun ammunition, or airplanes. The methodological problem was particularly difficult with ROLAND's multinational approach to selecting a system because of varying national estimates, expressed in hardware design, of all-weather, most-weather, or clear-weather threats, and the variously estimated performance of Soviet aircraft.

To put the all-weather (or most-weather) issue to rest, in March

of 1973 the US Army chartered another study, the Short Range Air Defense Study (SHORADS), under the direction of Brigadier General Robert Fye, which by August of 1973 could announce that an all-weather requirement did in fact exist. The signal was given; licensing negotiations between competing companies would begin, with the Hughes/Boeing team, for example, proceeding from a General Agreement with Euromissile, signed in October 1972, to a firm License Agreement, signed in November 1973, to compete ROLAND in the weapon selection that now seemed likely to occur.

CROTALE, RAPIER, and ROLAND

While studies were being prepared by TRADOC on the doctrinal and theoretical side, research and development activities proceeded apace on the technological side. Thanks to the discipline of money, each of the European corporations was aware of the US Army's efforts and needs relative to air defense systems. Each took the requisite steps to insure that the Army would evaluate the three possible contenders—CROTALE, RAPIER, and ROLAND—by making use of the "unsolicited proposals" provisions of the Armed Services Procurement Regulation.

In April 1970, Thomson CSF, Bagneux, France, submitted an unsolicited proposal to the Office of the Chief of Research and Development, US Army (OCRD) offering CROTALE. A US team evaluated the system during a 3-week, on-site inspection, and in 1971, CROTALE was examined at Fort Bliss and at Redstone Arsenal. Five live firings were included in the test program.

In June 1971, British Aircraft Corporation (BAC) submitted an unsolicited proposal to OCRD offering RAPIER. Under a UK-US Memorandum of Understanding, demonstrations, with all-weather elements, which included 12 live firings, were conducted in the United States in 1972, and in the United Kingdom in 1973.

The tests attracted considerable attention within the Army. Over 100 general officers observed the tests at one time or another, and 38 different kinds of tests, including hundreds of tracking exercises, were conducted to match actual performance against claims of performance.

In December 1971, Union Pour La Vente Des Produits submitted an unsolicited proposal to OCRD offering ROLAND II. The proposal was submitted on behalf of two corporations: Messerschmitt-

Bolkow-Blohm (MBB), Munich, and Societe Nationale Industrielle Aerospatiale (SNIAS), Paris. Under a Memorandum of Understanding among the United States, Germany, and France, ROLAND was examined in the spring of 1973, in a program which included seven live firings in the United States; this was while the SHORADS study was in full swing.

For US corporations, the problem presented was to estimate what threat the US Army perceived, what system the US Army would perceive as best meeting the requirements, and which of the European contenders would offer the most favorable licensing terms.

For the European firms, since the design of their weapons was a *fait accompli*, the problem was to judge which US corporation could best, and most profitably, represent them in the labyrinthine US weapons system acquisition process.

RAPIER, British Aircraft Corporation's contender, offered a typically fine quality product. RAPIER was designed, however, as a clear-weather, daytime optical system. BAC, and its eventual US licensee United Aircraft, would have to rely on an uprated BLINDFIRE all-weather version for success. From the Hughes point of view, RAPIER, and its all-weather RAPIER/BLINDFIRE employing several vehicles, appeared unlikely to meet the US Army's requirements in the most cost-effective way.

CROTALE, the French system, in US tests proved to employ the most advanced techniques of the offerings. The high-performance missile was first-rate; the launch and control system was impeccable, being able to sort out 30 targets at once and engage the one selected. Engineering for human well-being was carried forward to the ultimate—since the computer required air conditioning, why not give the crew an icewater tap? CROTALE did. Gold plated? Possibly so, inasmuch as the Union of South Africa provided the initial R&D funds and Libya was an initial customer. Several interviewees pointed to these connections, apart from CROTALE's expense and multivehicle design, as contributing to CROTALE's nonselection. In Hughes' view, CROTALE would not be the best choice for them, among other reasons, because of Thomson CSF's demands for very high front-end licensing fees. CROTALE's eventual US sponsor became Rockwell International, an excellent organization.

Hughes, Boeing, and Euromissile

Hughes' evaluation led the firm to decide that ROLAND II would be the Army's choice and to decide further to compete for SHORAD only if the corporation could obtain the ROLAND license. This posed a dilemma. Hughes enjoyed excellent relations with CROTALE's Thomson CSF and RAPIER's BAC as a result of numerous previous joint efforts; conversely, Hughes competed heavily with Euromissile in the antitank missile field: Hughes' TOW versus Euromissile's MILAN and HOT. In what a Soviet reader might find a contradiction of terms in capitalism, Euromissile and Hughes would find no barriers to cooperating in ROLAND due to competition for profits elsewhere. in fact, a Soviet might find the teaming a better example of "Socialist Competition" than many indigenous ones from Bezimenniy Gorodinsk.

An event that could not be foreseen at the time, of course, was the near successful sweep to power of the Left Alliance in the March 1978 French elections. One of the Left's announced platform planks was the complete government takeover of Aerospatiale. The continuation of US cooperation with a socialized industry in a Communist-dominated country, or for that matter, a continuation of German cooperation in Euromissile, poses a moot question.

Boeing was also courting Euromissile for the ROLAND license. It appears not unlikely that the German side of Euromissile, MBB, pressed the Euromissile parent firm to license Boeing, if not as an exclusive licensee, then at least to the extent of including the company on the team. MBB held high respect for Boeing's disciplined way of doing business. The MBB executives viewed Boeing as a fairly conservative old-line organization, highly responsible to its stockholders. Moreover, Boeing owns a block of MBB stock so cooperative channels were to a degree already established.

Hughes, on the other hand, presented quite a different face than did Boeing. Hughes, a corporation typical of the highly advanced engineering companies that chose to situate between the Pacific Ocean and the San Andreas fault, achieves excellent technical results even though it is the exact opposite of conservative.

Hughes Aircraft Company's multicentric approach to design and management with each center (Canoga Park, Culver City, Tucson, and others) operating quite independently was to cause some initial difficulties due to a lack of strong "projectization" of its

management organization structure. The picture may be exaggerated when viewed through the prism of the US Army's elaborate project management hierarchies. However, Hughes' management structure undoubtedly contributed to Hughes' mistake in overestimating ROLAND II's maturity and underestimating the work required for its technology transfer.

In any case, Euromissile teamed with Hughes and Boeing as co-licensees. The combination would pay dividends in obtaining the degree of innovation necessary, and the discipline required, to reduce the design to practice.

The Army Team

As for the US Army part o' tne ROLAND team, a Department of the Army all-weather SHORAD System Task Force involving 30 people convened in September of 1973 to draft a Development Concept Paper, Concept Formulation Package, draft Development Plan, statement of the Required Operational Capability (ROC), and a draft Request for Proposal (RFP).

On 7 December 1973, the US Army Missile Command established the SHORADS Management Office (Provisional) comprising 21 people, which was housed in cramped and noisy quarters at the south end of Redstone Arsenal. The office was redesignated the Office of the Project Manager, SHORADS, in February of 1974.[2]

By writing the ROC, the Army indicated it was serious about buying a SHORAD system. This action immediately drew US firms, notably CHAPARRAL's Philco-Ford, to seek a role in the operation. Philco-Ford enjoyed the support of several congressional delegations and quite a few users of CHAPARRAL who trusted its growth potential.

The RFP was changed to eliminate the requirement that proposals be based on systems already in existence. At the same time a stipulation was added requiring that all parts be manufactured in the United States. There was no specific stipulation in the RFP for NATO interchangeability. According to Hughes and Boeing interviewees, their understanding was that, upon contract award, the winning US corporation would obtain a Technical Data Package (TDP) of the European contender and build a US edition to US standards and practices.

On 29 July 1974, 21 sources were solicited. Four sources replied: Hughes (ROLAND II), Philco-Ford (all-weather CHAPARRAL), United Aircraft (RAPIER/BLINDFIRE), and Rockwell International (CROTALE).

The Source Selection Evaluation Board. A Source Selection Evaluation Board (SSEB) convened in September 1974 and began working 10-hours a day, 6 days a week; the team members worked on Thanksgiving Day, but rebelled at working on Christmas Day also. The Office of the Secretary of Defense (OSD) review was held on 8 January 1975, and on 9 January 1975, the US Army Missile Command (MICOM) awarded Hughes Aircraft Company, as prime contractor, a $108.4 million engineering development contract for US ROLAND. Since presumably mature ROLAND would not require the usual research effort of an engineering development contract, the effort was termed Technology Transfer, Fabrication, and Test (TTF&T).

Why, after a low-level approach since 1970, the sudden, frenetic action by the Source Selection Evaluation Board (SSEB)? It is because the convening of an SSEB brings individuals and organizations together from the four corners of the weapons acquisition world, each with often competing, even opposing, objectives in testing, financial auditing, cost estimating, reliability, value engineering, maintenance, training, and the myriad other aspects of the source selection process.

Since European ROLAND was a new experience for most SSEB participants, the oppositions, divergencies, and uncertainties must have been doubly difficult to resolve. Accustomed rules just did not fit the playing field or the shape of the ball. Moreover, because of the major dissimilarities among the four systems, four totally different support plans, for example, had to be formulated and costed to develop a usable cost effectiveness comparison. Part of the difficulty, too, was determining just where in the weapons acquisitions cycle, as prescribed in Department of Defense Directive 5000.3, to insert a Technology Transfer, Fabrication, and Test program. DT/OT II? DT/OT III?[3] The resolution was made prior to release of the RFP, but according to interviewees, various questions remained as to the maturity of the systems, hence their probable cost estimates, and increased the level of difficulty for the group. But the SSEB accomplished its part of the ROLAND task.

Staffing Problems. The Army met other obstacles in putting its part of the ROLAND team together. After receiving formal recognition

as Project Manager SHORADS in February 1974, Colonel Hank Magill and Mr. Edward Dobbins, his deputy, exercised selectivity in hiring people, trading time for quality to assure the right mix of abilities to handle a novel task. But in October 1974 an Army-wide hiring freeze was imposed which left the Project Management Office (PMO), at the time the contract was finally awarded in January 1975, truncated with no more than 31 of the authorized 61 people aboard. Although reinforced by allowable temporary detail (120 days under Civil Service Commission Regulations), it would be June 1975 before the freeze was lifted and people began to fill the desks on a permanent basis.

Personnel problems continued. Reduction in force actions—which is to say, individuals made available by reductions in force elsewhere in the bureaucracy—influenced who joined the team. Many newcomers were just not suited for project management work. Some were forced in, looking to their last job before retirement; others simply could not adjust to making quick decisions, often on the basis of partial information, and then being held responsible for the decisions. Special personality traits are necessary for project work. Time and circumstances gradually resolved the personnel problem.

On 7 July 1975 the project office was redesignated the US ROLAND Project Office and in early 1976 the Project Manager (PM) was upgraded to flag rank. Brigadier General Frank P. Ragano who was designated PM is a thoroughly professional Ordnanceman, and proved to be an excellent choice. He was selected Outstanding PM in 1978 by the Secretary of the Army.

By June 1976, the personnel authorization had expanded to 106 civilian and 17 military personnel. Moreover, the quality of staffing had by then greatly improved and was reflected in a competent, hard-working military and civil service project management team, who took pride in their unique role in NATO weapons management. The copestone was added when TRADOC implemented the "TRADOC System Manager" (TSM) concept, and identified by name an officer to represent the combat development side of the house and the user. The ROLAND TSM, Colonel Joe Hunter, reported through the Commandant of the Air Defense School to the Commander of TRADOC.

Action is often proposed to change US Civil Service Regulations which contribute to situations such as afflicted the early days of ROLAND. But certain rules and practices seem to go on forever. One

is the Civil Service Commission's Regulations and another is Parkinson's Law. Although the "promotion" of the project to general officer rank coincided with a move to fancier quarters on main post, as Parkinson's Law suggests, people preferred the hubbub and confusion at south post. "Everybody knew what everybody else was doing. If you had a question . . . and God, did we get questions . . . you could always yell over the divider."

The ROLAND team was assembled.

CHAPTER IV ENDNOTES

1. US ROLAND Project Office Historical Report, 1 December 1976, US ROLAND Project Office, Redstone Arsenal, Alabama; p. 2.

2. Ibid., p. 29.

3. DT/OT II and III—Design Tests/Operational Tests are performed at several stages of system development using procedures currently in effect (DOD Directive 5000.3). Design Tests evaluate technical performance; Operational Tests evaluate tactical performance. Both kinds of tests use earlier requirements documents against which to measure system progress. The puzzle of where to insert ROLAND's "TTF&T" was not limited to choosing among the kinds (Phase II or Phase III) of testing per se, but the tests did provide convenient identifiable milestones for definition of "TTF&T."

CHAPTER V

EXPECTATION VS. REALIZATION

Before the ink on the contract dried, major surprises confronted Hughes, the Army, the Office of the Secretary of Defense (OSD), and the Congress, like an abatis of trees felled across a forest path. Divergencies of expectations among the various participants, which existed only as latent images before contract award, emerged in sharp focus as conjecture became reality and concepts were translated into hardware design.

Until contract award, the Army procurement establishment expected, and intended, only to save R&D monies, and time, by having a US corporation obtain a Technical Data Package of an extant system and build a US version of that system. At Redstone Arsenal, interoperability was not even in the vocabulary. One interviewee remarked, "The first time we heard of 'I squared' [international interchangeability] was when this Dutch Colonel visited. . . ." This was perhaps an overstatement, since Redstone Arsenal has been involved in international cooperative projects for years, but nevertheless accurate insofar as the ROLAND effort was concerned.

Most of the congressional activity discussed in chapter 1 followed the formative effort leading to ROLAND within the materiel organization, as did the DOD memorandum formalizing the rejuvenated policy favoring NATO standardization. Although it appears likely that "NATO RSI" marched up front in the vocabularies of several senior Members of Congress, a few members of their staffs, and senior uniformed and civilian members of DOD and Army staffs, effective measures to implement the policies at working levels were to come much later. Consequently, the RFP issued from Redstone Arsenal did not address RSI per se, but negotiations called for a one-page estimate of the percentage of parts in the European system which would find equivalents meeting US specifications and standards. In Washington, on the other hand, various people in Congress, the Office of the Secretary of Defense, and the Office of the Joint Chiefs of Staff (OJCS) expected something closer to a Chinese copy or at least a built-to-print product essentially identical to the European original. Hence, they were aghast to hear stories of "Americanization" to include mounting ROLAND on a US vehicle.

Beginning in January 1975, in an exchange of letters between Senator McIntyre, Chairman of the Subcommittee on Research and Development of the Armed Services Committee, and Secretary of Defense James Schlesinger, the Senator expressed concern about the evident divergence between Euromissile's ROLAND II and Hughes/Boeing US ROLAND. The thrust of the Senator's rationale was that "it makes no sense to have the same weapon systems employed by US and European allies in the same theater of operations against a common enemy, with the basic weapon system or major components being significantly different and therefore not interchangeable."[1] More specific and immediate impact derived from Senator McIntyre's letter only 20 days after contract award directing the maximization of interchangeability, expressing surprise that differing US and European requirements were driving designs "which differ significantly" from the European, and taking umbrage at the proposed 5-year, 4-month development schedule for a presumably developed system.[2] Disillusionment would increase as Hughes revealed an estimate of $2 million (US dollars) to incorporate the "new" interchangeability requirement, a figure which later grew to $30 to $40 million, and eventually to $80 million to incorporate interchangeability and effect technology transfer.

Hughes/Boeing were also in for surprises as they found Euromissile's ROLAND II not as mature as they had thought, and as the Army expressed requirements which varied from the original expectations of Hughes/Boeing engineers. Data flow from Euromissile was slower than Hughes anticipated, partly due to changes still being made and partly, as Hughes/Boeing and the PM would soon learn, because of the variances in quality and lack of standard documentation practices among the 13 or so European subcontractors. Design changes for the radar were to continue into 1977, compounded by an increase in transmitter power deemed necessary by the US Army to meet the level of electronic countermeasures (ECM) threat Army analysts believed to exist.

Euromissile's expectations of assured profits from license fees and royalties, as well as expectations of protection of their proprietary rights by the straightforward wording of the licensing agreement, were likewise due to be thwarted. The managers of the firm were happy to read in the 10 January 1975 *New York Times*, an article announcing the US Army's selection of French-German ROLAND II, with a potential $100 million purchase of ROLAND over 10 years. Their smiles turned to grimaces, however, when an article in the Paris-published *International Herald Tribune* announced in February

that, subsequent to exchanges of visits by the Defense Secretaries of the United States and Norway, the Norwegian Storting had voted to purchase $108 million worth of ROLAND systems from the United States.

The Hughes/Boeing/Euromissile License Agreement

The language in the Hughes/Boeing/Euromissile license is quite explicit. At risk of excessive length, the pertinent section of the agreement is quoted to provide the full flavor of the issue and an appreciation of the sharpness of the chagrin:

> THIS AGREEMENT, entered into as of this Ist day of October 1972, by and between:
>
> Euromissile, Groupement d'Interet Economique, governed by French Ordinance no. 67-821, dated 23 September 1967, filed in the Register of Trade in Paris under no. 72 C 145, having its registered address at 37, boulevard de Montmorency, 75016 Paris, France, and having as sole partners S. N. I. Aerospatiale, Paris, France and Messerschmitt-Bolkow-Blohn GmbH, Ottobrunn bei Munchen, R. F. A. represented by its President General of the Army (GR) Jean Crepin (herein called "EUROMISSILE"), and
>
> Hughes Aircraft Company, a corporation organized and existing under the laws of the State of Delaware, having a place of business in Culver City, California, U.S.A., and The Boeing Company, a corporation organized and existing under the laws of the State of Delaware, having a place of business in Seattle, Washington, U.S.A. (herein called "Licensee").
>
> After having first recalled:
>
> That Aerospatiale and Messerschmitt-Bolkow-Blohm (MBB) designed, developed and carried out jointly as a working team the Roland II Radar Guided Missile Weapon System (herein called "ROLAND"),
>
> That EUROMISSILE, established by the aforesaid companies, has the right, title and interest in and to ROLAND together with the right to license third parties and to perform the obligations set forth in this Agreement;
>
> That the Licensee considers that the ROLAND weapon system covers a procurement program of the United States Armed Forces and that, therefore Licensee wishes to be in a position to

promote and to carry out its production solely for the use of the United States Armed Forces.

Amendment No. 2, December 1974, revised the restriction to read "to the U.S. Government for use by the U.S. Armed Forces and, if approved by the French and German Governments, for resale to third countries."

The Project Manager, meanwhile, having expected Hughes to serve as a strong managing prime contractor despite status as co-licensee from Euromissile, found at an In Process Review, 90 days after contract award, that organization and progress on the effort was unsatisfactory. Following normal practice, a Technical and Cost Reduction Assistance Contract (TACRAC) with various consulting firms had been pursued. As a result of the review, acquiring a TACRAC was to be accelerated. PM efforts also began developing normal, second sources of procurement for future competitive buys. But according to Euromissile, disquieted, and reinforced by Hughes/Boeing, these things were out of the question.

Under the license agreement all data remained proprietary to Euromissile. Accordingly, data would not be released even to operations research organizations performing on contracts in combat development activities sponsored by TRADOC or other DOD organizations, although these activities were related to other air/air defense analyses and were completely unrelated to the ROLAND hardware procurement effort. Second sourcing in the United States before a production contract award—which many in the US hierarchy took for granted—and the use of a Technical and Cost Reduction Assistance Contract with another party, were disallowed.

Further research revealed events which may have served to harden Hughes/Boeing's and Euromissile's stand. Much earlier the Army had made inquiries into the possibility of the licensing agreement providing unrestricted further use of the ROLAND data, but the suggested price tag—about US $300 million—led to dismissing the subject. The license limited agreement to an "exclusive right to manufacture."

Transient Frustrations

The Governments of France and Germany, having expected a solid pavement on ROLAND's two-way street, found themselves instead on a bridge peppered with potholes. Exercising arms

export/import controls similar to those of the United States, established during the 1930's era when all nations were curbing their Zackharoffs, Germany and France refused to approve amendments and allow TACRAC access to data until, first and foremost, third country sales were agreed upon, and rights and duties were controlled to their satisfaction. An intergovernmental Memorandum of Understanding (MOU) would have to precede further transfer of any data. It would be mid-summer before significant numbers of documents would change hands, and early fall (October) before the three governments would sign an MOU.

In the meantime, in the United States differences in expectation and realization continued to collide. People, particularly in echelons more remote from the workbench, seemed unaware of what happens when our developmental bureaucracies march out to bring new projects to life. For example, based on long and often anguished experience, documents carrying the weight of law require the use of Military Specification (MILSPEC), Military Standard (MILSTD), high-reliability (HIREL) parts. The estimated 90 percent correlation between Euromissile's parts and available US MILSPEC/MILSTD counterparts turned out to be only 60 percent.

United States safety standards for firing squibs of missiles required one ampere/one watt no-fire minimums. The Euromissile squib was built to 220 milliampere no-fire, 350 milliampere all-fire—a level US engineers believed would be randomly exceeded in the environment in which ROLAND must operate, causing inadvertent firings.

Initial test community proposals called for over 200 firings, including 2 at full-size aircraft, at a cost of a half-million dollars each. Budgeteers were astounded by suggestions for so many tests for a supposedly mature system. Multilocation tests, early in the program when test beds and spare parts availability would be at a minimum, would require magic and mirrors to be made workable if initial Operating Capability dates were to be met.

Both Hughes/Boeing and the Army Missile Command were surprised at their misestimate of the level of effort involved in "transferring the technology" and what such a transfer entails in real terms. This underestimate, plus the overestimate of the system's maturity, can only be blamed on the overoptimism of proponent contractor and government engineers and managers. It was simply a mistake. However, heeding intuition, further research revealed that in

the government case at least, virtually all the people involved in the initial evaluations were from R&D laboratories or R&D-related offices.

R&D people earn their paychecks by learning to live with the light at the end of the tunnel. In terms of personality and training the seemingly monotonous task of developing detailed drawings, data, and procedures necessary to replicate a technical component, in production quantities, at least cost, takes second place. In general, the farther one goes from the production shop floor, the less the realization of the size and scope of the engineering task; thus, in the halls of the Pentagon and the Capitol, there was great dismay at the enormity of the undertaking. The estimated 25,000 documents to be transferred turned out to top the 100,000 mark.

One may question using a name like ROLAND—the medieval knight who fought for the Frankish Emperor Charlemagne—to apply to a modern missile. But a Project Manager could certainly have used a knight's suit of armor in running the gauntlet of controversies that subsequently emerged.

Congressional staff members, though aghast at the 5-year, 4-month schedule, at the same time called for maximized commonality between US and European versions of the system and procedures which would achieve it. But they said little about how the procedures could be implemented without adding more time.[3] Department of the Army documents offered guidance directed at achieving interchangeability at missile level only,[4] saying nothing about the vehicle or fire control, while OSD guidance suggested going beyond missile level (at no cost) by establishing international mechanisms for configuration control. How these mechanisms would be established without cost was unexplained.[5] Interchangeability requirements drive the requisite degree of detail several levels of specification deeper than functional replication of design.

For ROLAND, the differences in expectation and realization were exceptionally severe. Standardization was blamed by some; destandardization by others. But all of the problems proved ephemeral rather than permanent; they were in fact more a result of unresolved differences in perception than real problems of engineering or system effectiveness.

Money, politics, and war would eventually find ways to resolve the problems and establish ROLAND not only as an outstanding system which contributed to NATO defense, but as an example of

what many perceive as the wave of the future in weapons procurement.

CHAPTER V ENDNOTES

1. Letter, Senator Thomas McIntyre, US Senate, to Honorable James R. Schlesinger, 10 July 1975.

2. Letter, Senator Thomas McIntyre, US Senate, to Honorable James R. Schlesinger, 28 January 1975.

3. Ibid.

4. Memorandum, Office of the Assistant Secretary of the Army (Research and Development), for Director of the Army Staff, 23 December 1975, subject: ROLAND Program.

5. Memorandum, Director of Defense Research and Engineering, for Assistant Secretary of the Army (Research and Development), 21 November 1975, subject: ROLAND Program.

CHAPTER VI

HOISTING THE MAINSAIL; SETTING THE JIB

The ROLAND project was like a ship adrift in water—too deep to anchor, yet unable to make sail. Before the project could begin, the kaleidoscopic images of what US ROLAND should or could be had first to take an agreed upon form.

First, the US, French, and German Governments would have to agree on a Memorandum of Understanding sorting out third country sales and formally establishing a policy of maintaining as common a configuration as feasible. Memorandum Number 1, signed in October 1975, solved the problem and established general terms of trinational cooperation on the ROLAND project. To avoid further acrimony, a special agreement was reached in a one-page supplement concerning Norway which allowed purchase of US launch stations and European missiles. The agreement reportedly remains in its handwritten form, with each party fearing that trying to put it in a more formal format might result in its retroactive reconsideration.

Next, the United States would have to get agreement from Euromissile to allow earlier "second sourcing" in the United States, to obtain sufficient rights in data to support ongoing OR/SA studies, and to allow a Technical and Cost Reduction Assistance Contract to extend the limited resources of the Project Manager. Also, the US DOD disagreed with the front end payment of production license fee (DM 64 million) and insisted on amortizing the fee over the production contract period. But how could the governments intervene in a legally proper license already agreed upon between Hughes/Boeing and Euromissile?

Money and politics solved these problems. The United States wanted assurance of a lower price and expanded mobilization production by means of second source competition. Euromissile needed the US infusion of money to achieve the full potential of ROLAND II. Buying all European was not an option the United States would consider. Moreover, European firms are reluctant to expand employment for a transitory wave of production due to the extensive social elements, especially job security, in European labor contracts. Hughes/Boeing and Euromissile found a way to agree to their mutual advantage.

At the Project Manager level, these kinds of problems led to assigning a legal officer to the PM staff. However, the assignment was not permanently established until March of 1976, well after problems had taken the lead over available remedies.

Managers in the United States, from Congress to the shop floor, would have to agree upon the ultimate extent of standardization between US ROLAND and Euromissile ROLAND. From Hughes' plant in Canoga Park, Boeing's in Seattle, MBB's In Munich, and SNIAS in Paris, an international mechanism would have to be agreed upon to manage the cooperative aspects of the standardization program and, especially, come to grips with the technology transfer. Propelled by Senator McIntyre's letter of January 1975, the intergovernmental structure was established in April 1975, well in advance of the signing of the October 1975 Memorandum of Understanding.

International Aspects of the Program[1]

In organizing the ROLAND project management office, Missile Command headquarters followed the structure prescribed by their own regulations and by regulations generally employed throughout the Army Materiel Development and Readiness Command. At the time the project management office was initially organized, little of the future requirements deriving from the novel international nature of the project, and less of the intensive management by higher headquarters—similarly prompted by the novel and untried approach to the project—were foreseen. As the problems began to unfold, organizational changes were undertaken in response.

A particularly illuminating example of the effect of international standardization on special organizational requirements can be found in the establishment of the Joint ROLAND Control Committee (JRCC). This structure created a "multilateral organization for the definition and implementation of common interests with regard to the ROLAND II weapon system." With the JRCC acting as a program focal point, the participating countries agreed to seek an optimum level of standardization and interoperability of the ROLAND, with the object of maintaining a common configuration to the maximum extent feasible. Furthermore, the participating countries agreed to strive for a maximum of commonality in such areas as training and logistics and, where a demand appeared, for increased efficiency. In keeping with these objectives, the participating countries agreed to establish and maintain an organizational structure and relationship to:

—Exert tight control over modifications and improvements which affect the baseline configuration

—Establish and sustain an optimum level of system commonality, interchangeability, and compatibility

—Minimize duplicate efforts between the programs

—Investigate and implement activities of mutual benefit

—Identify problems affecting both the European and American programs and develop solutions acceptable to the participating countries

The JRCC membership consists of representatives of the French and German Ministries of Defense and the US Department of the Army—that is, the US ROLAND Project Manager.

The following joint subcommittees were set up as the working elements of the JRCC:

Joint Test Subcommittee (JTS)

Joint Logistics Subcommittee (JLS)

Joint Training Subcommittee (JTNGS)

Configuration Review Group (CRG)

Simulation Central Coordination Subcommittee (SCCS)

Threat Subcommittee (TSC)

The title of each of the various subcommittees accurately describes the purposes for which they were formed. Like the JRCC, but only for its specified discipline, each subcommittee constituted a small multinational organization created for the definition and implementation of items of common interest. Agreements reached within the subcommittees are presented to the JRCC for ratification. Differences between members which cannot be resolved at the subcommittee level are elevated to the JRCC for resolution. If resolution cannot be obtained at the JRCC level, differences are elevated to the national level for resolution (Director of Defense Research and Engineering for the United States and the armaments

directors for France and Germany). Figure 1 depicts the organization of JRCC.

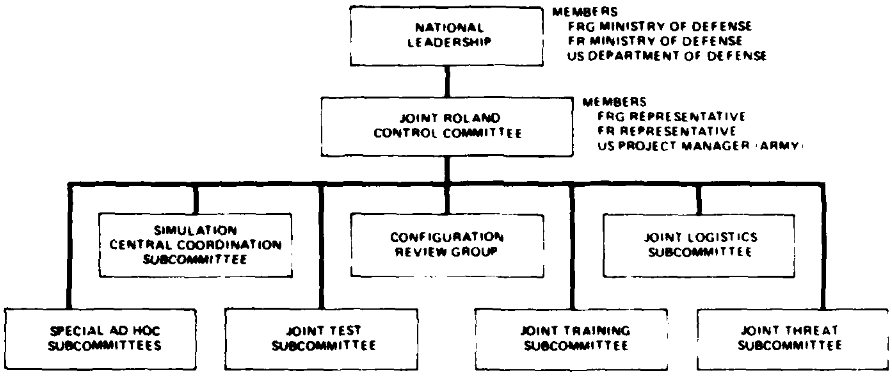

Figure 1. Organization of the Joint ROLAND Control Committee

Naturally, the intergovernmental committees alone were insufficient. Actual accomplishment would require contractor participation, which was added by Modification 17 (about $500,000) to the Technology Transfer, Fabrication, and Test Contract, fleshing out the JRCC as indicated in Figure 2.

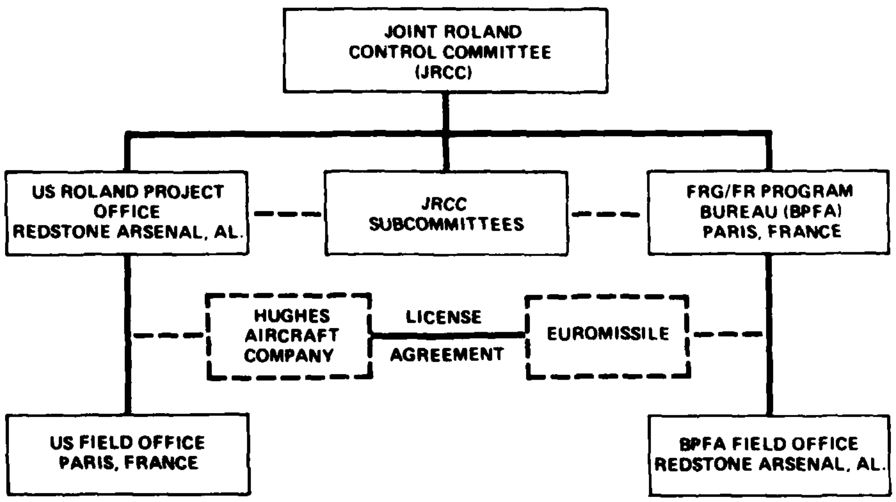

Figure 2. US/European ROLAND Coordination Structure

The Bureau de Programmes Franco-Allemand (BPFA) corresponds to the US Project Management Office (PMO) at Redstone Arsenal. BPFA represents Germany and France in the administration of contracts with Euromissile. Typical of the differences in industry-military relationships between the US and European NATO members is that BPFA had only 30 people and managed HOT and MILAN as well as ROLAND. However, BPFA, when compared with a US-style PMO, would be found wanting in scope of action and speed of response, problems which plagued the US schedule-driven effort in many cases.

An appreciation for the size and scope of operations as the ROLAND project organization coalesced can be gleaned from Figures 3, 4, and 5.[2]

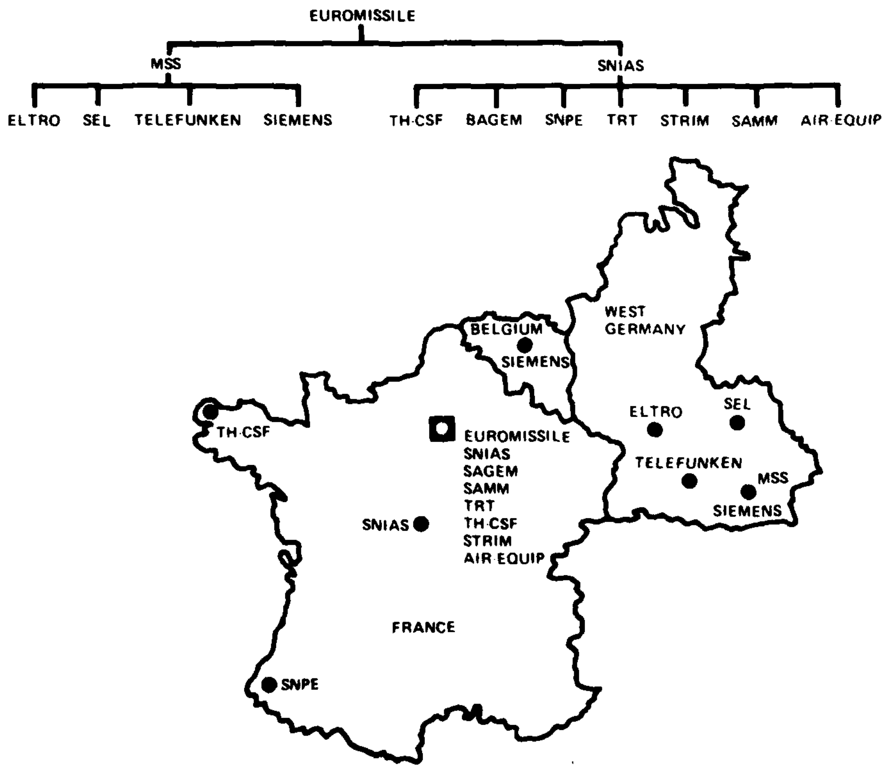

Figure 3. Euromissile's Major Contractors

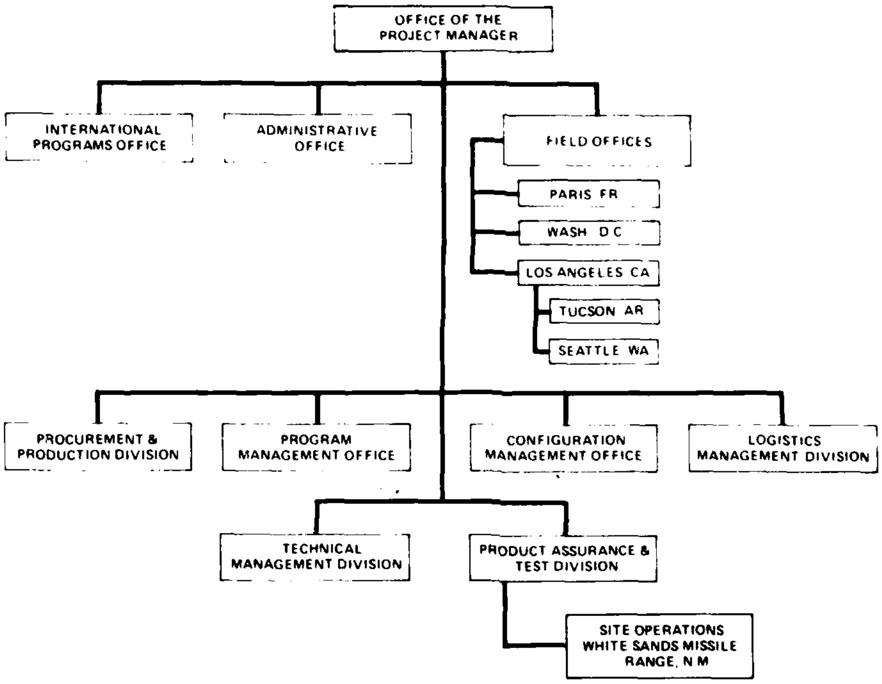

Figure 4. Organization of the US ROLAND Project Office

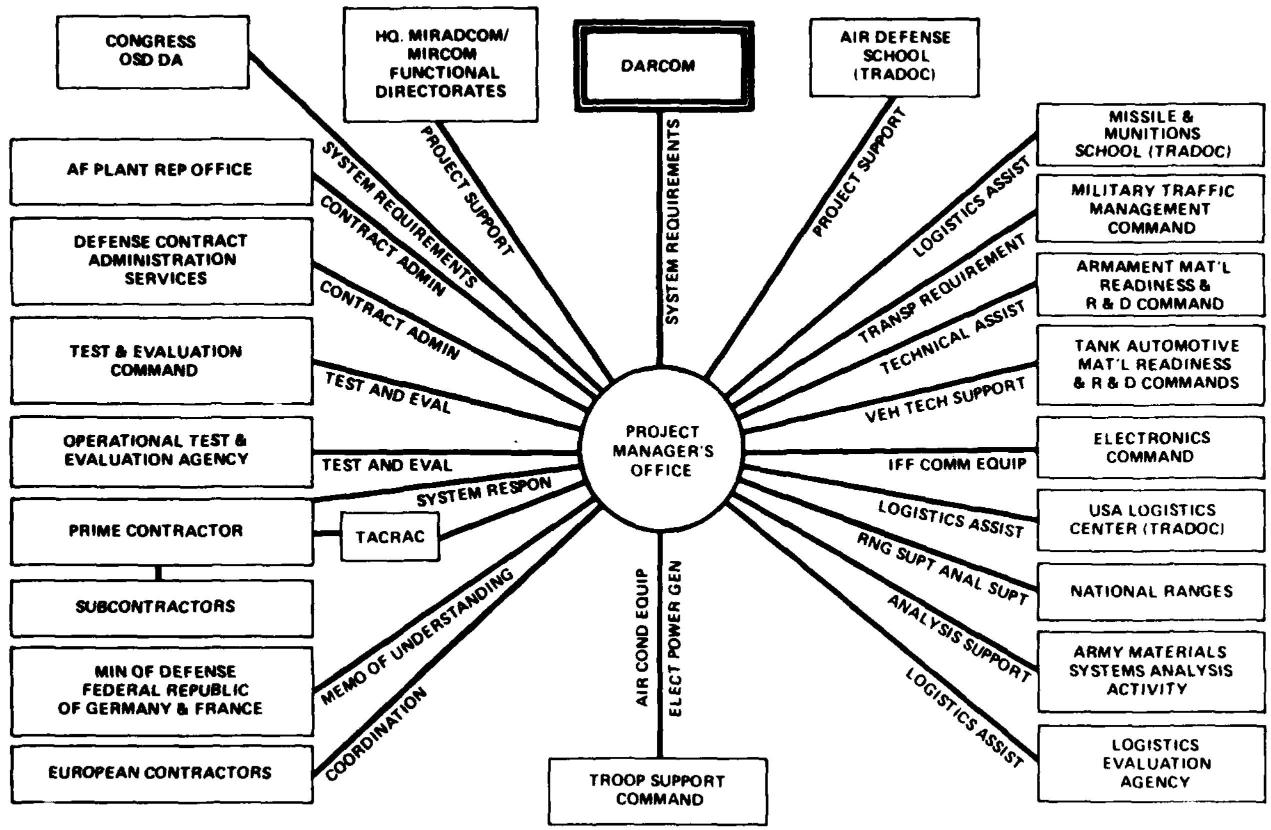

Figure 5. Organizational Interfaces for Management of ROLAND II

For 5 weeks, beginning in September 1975, the PMO, under the leadership of Mr. Edward Dobbins, Deputy PM, conducted a detailed review of the program and the projected cost growth identified by Hughes/Boeing, taking into account the international standardization requirements. The report of the US ROLAND cost "Red Team" provided a thorough, line by line, item by item, evaluation of cost projections, management systems, and structures. It recommended adjustments in every case. Most significantly, the Red Team report pinpointed the definition of interchangeability which hoisted the mainsail for ROLAND's technology transfer—"components can be interchangeable without being identical. They are interchangeable as long as their parameters are within form, fit, and function system requirements."[3]

With a few exceptions, "form, fit, and function" put engineering in the driver's seat in determining how US ROLAND would take shape. The definition already was written into Modification 14 of the contract. Despite the definition's contractual specificity, authors of the Red Team report forcefully reemphasized the requirement, demanded compliance from their still otherwise inclined prime contractor, and recommended that the PM get higher authorities to specifically approve the terms of "form, fit, and function." The perhaps lightly chosen words proved heavily significant.

Exceptions did occur which caused controversy. The firing squib problem, caused by differences in US and European interpretations of what constituted a safe voltage to prevent missile firing due to random electrical discharges, was handily resolved by internal redesign of the circuitry. Although the internal black boxes differ, the missile remains interchangeable with French, German, or US fire units, achieving form, fit, and function at least for the missile itself.

The radar was judged by US engineers as insufficient for the estimated Electronic Countermeasures (ECM) threat. United States engineers believed a more highly powered transmitter would be required to burn through jamming. Further research revealed that the strength of the European design was considered adequate by their engineers if the ECM tactics of the Europeans were also adopted. The differing approaches provide an example of the valuable aspects of nonstandard armies and tactics which require an attacker to handle both modes. The rest of the radar system (96 percent), which retained the same form, fit, and function, and the missile guidance system, remained unaffected.

Two items that continued to be controversial in the standardization-Americanization arguments were germane or irrelevant, major or minor, depending on the observer's position in the hierarchy, his familiarity with the weapons development process and organization, and consequent point of view. These items were the auxiliary power unit/environmental conditioning unit and the choice of vehicle. The Hughes white paper pointed out that there was never an intent to license either. Under the Packard memorandum's licensing ground rules the question is then thrown to the government, "should there have been?"

Generators and air-conditioning units occupy a special niche in the weapons acquisition milieu. Efforts to standardize sizes, outputs, and component parts, just in the United States, have over the years been considerable. Earlier, proliferation of types impacted upon requirements for military occupational specialties, created training problems, and resulted, for a time, in much equipment in the field that could not be kept operational. Why take a step back, argued the advocates of using US standard items, when proven, military-qualified, off-the-shelf componentry was easily at hand?

More important was the choice between standard European 50-Hz and US 60-Hz electrical systems. The 50-Hz system was chosen to maintain as much interchangeability as possible in the form, fit, and function of internal components dependent on one or another cyclic rate. Choosing off-the-shelf military-qualified components and the 50-Hz power offered the best of both worlds. Naturally, the preserved NATO interchangeability did not come without cost. The trainer cannot be plugged into US line current, and the trainer is no small consumer of electrical power.

The vehicle issue falls into an area of ordnance engineering characterized by formally and informally institutionalized efforts to standardize the US vehicle fleet. A major command, the Tank Automotive Command at Warren, Michigan, parallels the Missile Command at Redstone Arsenal, performing similar functions in the tank/automotive commodity area. This command would, of course, exert considerable influence in selecting a proper vehicle. Major equipment programs, such as replacing M59 armored personnel carriers with MI13's, go well because of their mass volume. Secondary applications, involving much less fleet density, such as for recovery vehicles, mortar carriers, and the like, always lag behind. Also, in the weapons engineering field, a trend developed over the years to modularize equipment such as ROLAND into equipment pods or

shelters to maintain its transportability, and if the equipment pod is light enough to provide for helicopter transport. German ROLAND is hard-wired into a version of the Rheinstahl AG Schutzenpanzer, a widely distributed infantry combat vehicle backed by a broad maintenance and parts base in the Bundeswehr. The French ROLAND is integrated into GIAT's AMX-30 tank chassis. RAPIER comes in modules in tracked and towed versions.

That a US producer would modularize and seek his own vehicle rather than adopt a vehicle totally alien to the US parts and maintenance stable appears to make good sense, and with institutional momentum behind it, could be expected. But form, fit, and function of control consoles remain the same. French or German operators will be at home in US ROLAND as will US operators in the Spz or AMX. To be sure, choosing a vehicle other than the Spz or AMX, which appeared to surprise many people in Washington, was not a casual decision. A series of studies, beginning with Boeing's review of 30 possible candidates in January 1974, and culminating with an Army Staff review in January 1976, were conducted before an April 1976 decision was made by the Under Secretary of the Army to deploy all ROLAND units on the M109 chassis—the tracked self-propelled carriage for the widely distributed 155 mm Howitzer. Although the decision sorted out the issue of which vehicle to put in the field, cost estimates were further confounded because original bids were based on an articulated, wheeled all-terrain vehicle.

The vehicle choice points up one of the dichotomies in NATO standardization. Using a single vehicle for all ROLAND systems might standardize a low density weapon system among all users, but destandardize each individual nation's fleet. However, because a secondary use vehicle lacks the political ramifications of, say, a tank, developing a standard secondary use vehicle for a variety of secondary uses (such as recovery and command posts) might provide both the NATO standardization and the volume required to develop a solid parts and skills base in each force. According to one engineer in the ROLAND project, standardization of components of power supplies and environmental equipment offers a similar opportunity. Each country could manufacture its own components but all would be commonly supportable in the field.

There were other ROLAND components which received similar management by exception, but by and large, "form, fit, and function" served as the mainsail that determined the course for the system Hughes/Boeing agreed to produce.

Next, US maintenance and logistics procedures set the jib. A difficulty facing logisticians in absorbing a "technology transferred" system is that planning and design of maintenance equipment, and provisioning of spare parts, begin late in the total process. In the case of ROLAND this difficulty was compounded by the European maintenance philosophy which places greater reliance on factory support than is the case in the United States. Additionally, the Europeans lack the procedures, publications, and extensive Military Occupational Specialties planning of activities that characterize the US logistics system. With regard to ROLAND, which was proposed with an Organizational Maintenance Test Set (OMTS), a Field Maintenance Test Set (FMTS), special tools, and a trainer, the FMTS which the PM expected to see in the data transfer just did not materialize. The Red Team report led to the United States developing a national FMTS—a task not priced out in the original bids—as the best course of action. Having to play catch-up ball in a technology transfer should be recognized as impacting on logistics staffing of the project. Fortunately for ROLAND, exceptionally well-qualified logisticians were given the catch-up task.

Fixing the level of interchangeability to form, fit, and function helped set the course for determining the level of test activity as well. The Joint ROLAND Control Committee (JRCC) agreed that if a component performed to bench checks on form, fit, and function, successful operational test of a European component would suffice for the United States and vice versa. The United States and Germany signed a Memorandum of Understanding for a cooperative test program in February of 1975, adopting a joint test philosophy and establishing the Joint Test Subcommittee, and as part of the JRCC further improved the test schedule. A series of rescheduling exercises culminating in the efforts of the US ROLAND Test Review Team led by Major General P. W. Powers, Commanding General of the US Army Test and Evaluation Command, would see the required number of firings reduced first from 300 to 200, then to 100, and finally to 60 US firings, meshed with tests and firings in Europe.

Complications emerged in the test program from European complaints that despite agreements to act as codirectors with them, the United States tended to take over management of the program. Europeans possibly expected the same low-key approach experienced in the earlier demonstration tests under the Missile Command's control. However, as the more structured Test and Evaluation Command program took hold, the informal arrangements disappeared. United States predilections for meeting schedules, even

if requirements change, and the relative size of the US, German, and French test communities undoubtedly contributed to the perception of exclusive US management. So, too, did scheduling constraints imposed by the Congress on the US Army. These constraints were such that if a test failed, no time was allowed to find and correct the cause of failure, or for the decisionmaking process at higher headquarters in accordance with the various review and decisionmaking procedures prescribed by DOD Directives and Army Regulations. But those vexations that did occur in the testing community were eventually mollified.

Further research revealed that the extensive direct involvement by certain congressional staff members and the insistence on a tight schedule were driven in part by the necessity to be proven right in supporting a foreign purchase. Saving money, according to interviews, was the overriding objective. Lengthy schedules and extensive testing to transfer a presumably developed system did not make sense and did not save money. The involvement was not just to avoid embarrassment. ROLAND had to succeed in fending off the factions who oppose foreign buys in general and in giving a fair chance to the concept of rationalization and interoperability by licensing in particular.

Intensive management, indeed overmanagement, characterized several phases of US ROLAND's evolution, and the management style was distinguished more by brute force than by finesse. This is exemplified in the adaptation and development of ROLAND's management control system. Contracting officers initially wrote in a PERT-like[4] system in the Contract Data Required Documents List (CDRL) but later deleted it when they learned the price. There seems to be a constantly operating divergence between contract managers and systems managers. Each profession is educated and professionally developed along different paths, which causes a hesitancy on the part of contracting officers in getting a technically oriented, but simple network management scheme underway. Contracting officers prefer the more familiar Scope of Work approach; system managers prefer Program Evaluation and Control Technique (PERT) or something like it, but usually cannot afford it; the Cost Schedule Control System (CSCS) is financially based and misses the technical interrelationships wherein usually lie the causes of financial problems.

The contracting officer's uncertain trumpet also reverberated across related problem areas. Contractors like to reveal very little; the

government likes to hear a lot. Contractors generally win because, inadvertently, their pressures interact with the government at the traditional weak points of organizations, including military forces in the field, which is to say, the boundaries of responsibility. Traditionally, the functional division of Army Commodity Commands splits R&D (projects) and procurement (contracts). The two functions are also usually separated in office space and in time of activity.

Most project offices, as was the case with ROLAND, do not become active until most of the Requests for Proposal and contract preparation are complete. One of the arguments within government organizations favoring subordination of contracting officers to prcject managers is the desirability of introducing a sound management system in the early stages of a project. But during the formative phases of a project there is insufficient work to justify either a full-time contracting officer or a significant management system office typical of later project stages.

As the management system element becomes fully operational, and ROLAND's provides an excellent example, the traditional Scope of Work used in contracting by Army procurement agencies has to be tediously cross-indexed to the CSCS work packages or whatever management elements comprise the selected management system. If these elements do not mesh, one cannot measure, and if one cannot measure, one cannot manage. ROLAND's fine management system office encountered such difficulties in cross-indexing a Scope of Work to CSCS work packages. The Red Team report cites a number of problems deriving from the inability of a Scope of Work to provide adequately clear specificity.

Another management system problem with ROLAND was that the initial CSCS failed to identify the problem with cost growths that soon occurred. Because finesse of sophisticated management tools failed to accomplish its purpose, brute force had to be applied. A senior Army official deleted the credit for percentage completion of restructured "work packages" as was the normal CSCS practice and allowed instead credit only for 100 percent completed work packages. This action, in turn, simply led to proliferating the work packages, thus turning the management system into a ploy to obtain credit for artificially smaller packages. Internal company management tools comprised numerous Gantt charts. Eventually, ROLAND's management systems worked exceptionally well by using a high degree of data automation and by providing managers most of the visibility into the project they required.

The early experience with ROLAND, as well as with the wider sample to which this section alludes, points to a need to reexamine the area of imposition of various PERT, CSCS, or Scope of Work management control procedures. Experience suggests perhaps an organizational or pedagogical rather than a procedural solution to this problem. An organizational solution could lie in teaming accounting and procurement specialists with management system specialists in the functional organizational structure itself, rather than waiting for the project to grow to a size warranting a separate project management office. A pedagogical solution could lie in requiring applicants for certain contracting positions to possess a background in management systems. Service schools which provide instruction in the two fields could alter part of their curricula to accommodate this interdisciplinary approach.

Restructuring the Program

Difficulties discovered in attempting to effect the technology transfer, caused primarily by underestimating the task and overestimating the maturity of the system, crested in October of 1975. At that time, the full impact of the two misestimates, plus the reversal of field to accommodate interchangeability, was recognized, analyzed, and resolved. Army management recast ROLAND into a final restructured program that was negotiated into the contract.

The new contract, actually signed as Modification 73, in October 1976, specified a new price of $183.3 million. The efforts to review and restructure the ROLAND project were similar to experiences on other projects with comparable difficulties in the way of increasing costs and lengthening time requirements. Therefore, much of the criticism of the ROLAND project must be attributed to its visibility as a novel acquisition approach, its role as a political cause celebre (viewed favorably by some, unfavorably by others), and the overhead of extra factions whose traditional hunting grounds were being encroached upon.

Restricting credit to 100 percent completed work packages was cited as one example of overmanagement and heavy-handed control. Other examples that emerged as the restructuring effort got underway included the convening of 7 special reviews in 21 months, each equivalent to a major management review such as those conducted by the Defense or Army System Acquisition Review Councils (ASARC/DSARC), as compared to 8 or 9 over an 8- to 10-year period for an accustomed acquisition program, and, for about a

year, the imposition of month-by-month incremental funding. Both constituted burdens on an already overburdened effort, but the novelty of ROLAND's causes and results made the actions appear warranted at the time. As of this writing (July 1978) the last Research, Development, Test, and Evaluation (RDT&E) monies are expected to be spent in calendar year 1979 and production could begin in fiscal year 1979, both dates very close to initial estimates. Total RDT&E monies presently are projected at $276 million and the total US ROLAND program at $l.9 billion. The prime contract remains at the level restructured in October 1976.

Technical successes helped turn the managerial and political corner, transforming ROLAND into a healthy program with solid management, attainable goals, and a bright future. The first US-built optical sight was successfully demonstrated at the Hughes plant in Culver City, California. Hughes-produced missiles were successfully fired from European launchers at the test range in France. United States and European components and subcomponents were exchanged and found interchangeable. By the time of the second Executive Review at Fort Bliss In March of 1978, a US-produced fire unit successfully fired a US-produced missile at a target drone over the White Sands Missile Range, achieving warhead detonation within one meter of the target. Honorable Walter La Berge, Under Secretary of the Army, keynote speaker, could rightly point to a high level of excellence achieved by the ROLAND team in a successful international weaponization project.

The task ahead was to get ROLAND deployed with the Air Defense troops.

CHAPTER VI ENDNOTES

1. Description of JRCC taken from a pamphlet, US ROLAND Project Office, US Army Missile Research and Development Command, Redstone Arsenal, Alabama, November 1977.

2. Charts from same source.

3. US Army Missile Command Report of US ROLAND Cost Red Team, 6 October 1975 (Confidential).

4. PERT —Program Evaluation and Review Technique. PERT is a computer-assisted management system employing networks displaying the flow of project work. PERT first became known

through its application in the Navy's POLARIS missile project and in other Air Force and National Aeronautics and Space Agency high technology missile development undertakings in the 1960's. PERT is a fairly complicated scheme applying three estimates of cost or time requirements for the completion of precisely defined work packages in the network. These three estimates: *optimistic, pessimistic, and most likely*, applied against a Poisson or Beta distribution provided PERT an algorithm with which to cope with the large amount of uncertainty in accelerated development in large, high technology projects.

CHAPTER VII

TECHNOLOGY TRANSFER: THE VIEW FROM THE SHOP FLOOR

"Technology transfer" is a term in popular use but one that is not widely understood. The initial underestimation of the difficulties attendant to the technology transfer for ROLAND has been cited as the single major contributor to the early cost growth of the project, much more so than underestimating the maturity of the system. Because the task has now been successfully achieved, reviewing its particulars will serve as a good example of what technology transfer entails.

Standards and Measures

Each industrial nation has developed within its own infrastructure sets of standards and measures which pervade its engineering design. In US defense industries a set of Military Specifications (MILSPECS), Military Standards (MILSTDS), for parts and processes, and qualifications for high reliability (HIREL) parts has evolved to a high state of perfection. MILSPEC/MILSTD parts are required with few exceptions in designing all military equipment. Sad experience led to the imposition of a requirement for HIREL parts in missile applications by documents carrying the weight of law. High reliability parts, manufactured to more precise standards, subjected to more quality control, and built sturdier for more robust performance than normal parts, are, of course, more expensive. Their use, however, prevents a million-dollar missile from aborting because of a failed 50-cent electrical connector.

Because they are useful, MILSPECS and MILSTDS are widely diffused in civilian industry as well. Hughes/Boeing expected that of the 68,230 parts comprising ROLAND, a US MILSPEC/MILSTD counterpart could be found for 90 percent of them. As it turned out, only 60 percent initially qualified. The lower percentage surprised Hughes/Boeing engineers because, of the thousands of types of materials and processes in Euromissile's ROLAND, US materials and processes (but not necessarily shop practices) proved to be derived from US processes. Reluctance on the part of Euromissile to transfer data prior to award of the contract compounded Hughes' difficulty in making the estimate. Block diagrams and functional descriptions are not a substitute for wiring schematics and detailed parts/specification listings.

NATO nations as well as France have begun efforts to develop US MILSTD qualified parts lists which, with each successive joint project, will greatly simplify part-counterpart identification. As for ROLAND, the requirement written into the contract that all parts be US-produced would prove difficult if only a 60-percent correlation could be found between Euromissile parts and US-manufactured parts meeting MILSPEC qualifications. Particularly costly would be US replication of connectors made to European specifications. If form, fit, and function were to be the criteria for interchangeability, then connector families would have to be identical. One proposal was to eliminate the contractual provision requiring the production of all parts in the United States, at least until the production phase wherein higher volume would better amortize special tooling and process costs. For connectors, of which there are 32 families in ROLAND, an estimated cost of $1 million per family would have been required to tool up for production. The decision was made to buy European.

At the piece-part level, the significance of choosing between a "Chinese copy" and a "build to print" copy becomes more clear. The former would demand an exact copy of parts and their location in the US product. The "build to print" approach allows much more leeway in selecting parts, and in relocating parts to accommodate particular assembly tools or procedures familiar to US workers, and would thus be less expensive. Much of the argument insisting that HIREL parts are an expensive "Americanization" loses its cogency when the more serious considerations of choosing connectors, and other unavailable parts and processes for "build to print," or making a "Chinese copy," are introduced. But in any case the major technology transfer cost did not accrue from deciding on HIREL parts, even though their use in many cases required relaying some printed circuit cards; that is, rearranging the "wiring" and connections on the card, to accommodate the larger size of most HIREL parts.

The Technical Data Package

The major technology transfer cost derived from the large and tedious task of transferring the Technical Data Package (TDP) from Euromissile's subcontractors to Hughes/Boeing and their subcontractors. Mr. C. G. King, Boeing program manager, gave these figures at an American Defense Preparedness Association (ADPA) meeting: Developing a usable TDP required translation or conversion of 22,000 drawings, 4,000 specifications, 33,000 tooling, manufacturing, and bench test/evaluation plans, 7,000 standards, and 49,000 engineering change orders, revisions, and updates at a

cost of about $18 million. The interaction of underestimating the task and overestimating the maturity of Euromissile's ROLAND can be seen from the large number of changes that had to be processed. Also, the number of changes effected reveals the value of the disciplined engineering skills that were required to trace the changes through the hierarchy of poorly indentured (indexed) drawings and specifications for application to actual hardware on the shop floor.

Nor was the transfer all that straightforward. There is no European-wide counterpart of MIL-D-1000 which specifies how drawings will be made, what their quality will be, and, particularly, that requires an indentured structure, so that a drawing can be traced to its subcomponent, component, system, etc. Practices and quality varied from country to country and plant to plant, all of which required sorting out. Parts themselves were selected from European catalogues, in turn qualified to standards such as Deutsche Normen (DIN), Normenstelle Luftfahrt (LN), or Norme Francaise (NF). For example, using the annotation "std finish," on a drawing for a hydraulic piston led to confusion as to which finish to use. The piston continued to malfunction until the standards interpretation error was discovered.

For each part, a US counterpart search was conducted using the Army Data Retrieval Engineering System (ADRES) which, as the US ROLAND project shifted into high gear, improved the correlation of US MILSTD parts, commercial equivalents, or approximations to those of Euromissile. The final results, annotated on the qualified US drawings, are impressive:

Total parts	68,230
Exact US equivalents found	54,800
Near US equivalents found	4,000
European purchase	9,430

In the process of maintaining form, fit, and function of "field replaceable units" or modules, 600 of the items requiring field replacement proved to be interchangeable with European counterparts, and involved about 94 percent of the kinds of parts distributed throughout ROLAND.

Figure 6 depicts how the technology transfer of the TDP was achieved.

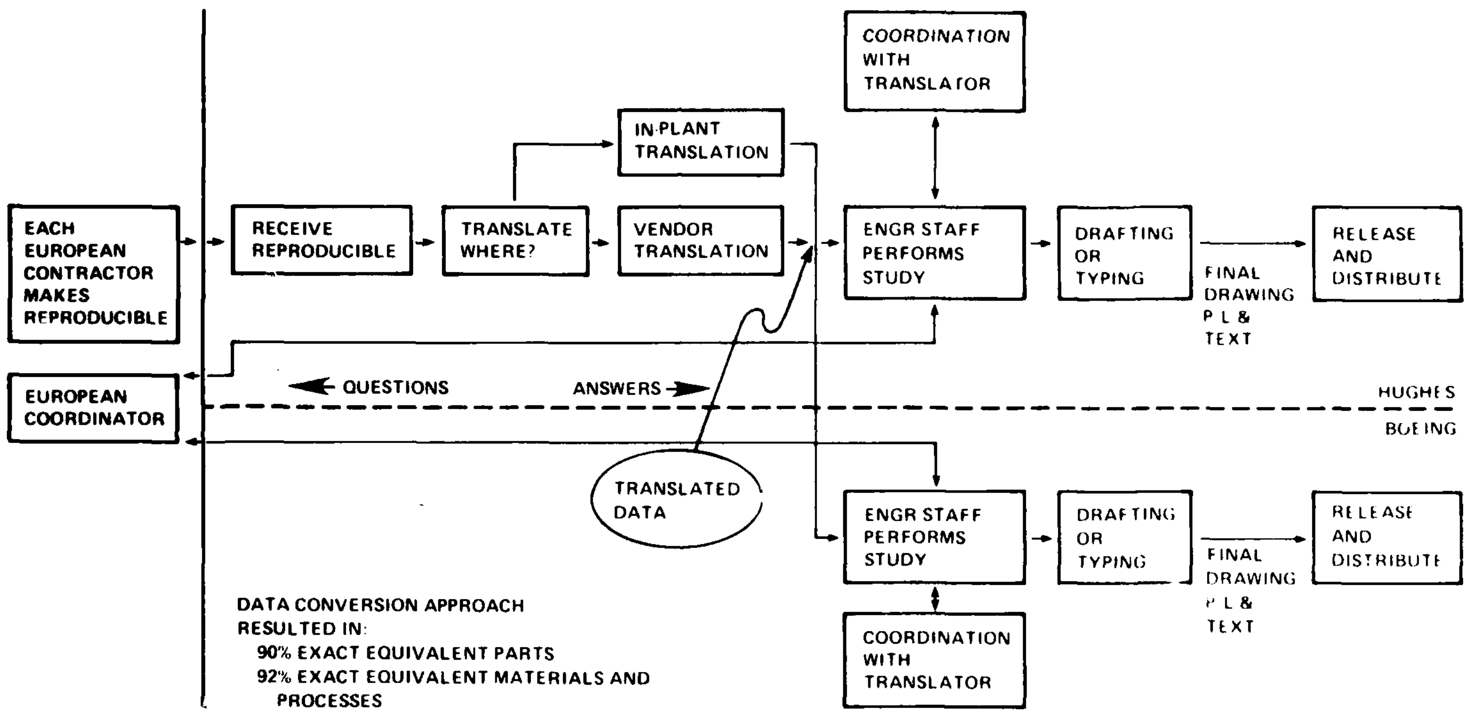

Figure 6. Data Conversion Approach

Accepting the higher costs necessary to transfer the TDP was much more palatable when viewed from the shop floor than when viewed from the halls of the Pentagon and the Capitol where the higher costs evoked considerable ire. The Congress had been confronted by unexpectedly large requirements for drawings before, in a much earlier standardization effort.

The Thirteen Frigates. **By the Act of 13 December 1775, 13 frigates of three standardized designs were commissioned with delivery due the end of March 1776. Building was assigned to the various colonies based on their relative political importance rather than on their shipbuilding ability. Design was assigned to the yards in Philadelphia.**

However, following practices in use at that time, the drawings were scaled to 1/8" to the foot. After 31 days to develop the design, and 20 more to make copies, it was discovered that there was no way to send the sets of bulky drawings to the shipyards. Ten days later, a paymaster's wagon train going to Boston was able to take two sets. The other colonies went ahead with nonstandard designs.[1]

Differences in Craft and Workmanship. Other aspects of technology transfer relate to deeper differences of craft and workmanship that go back to the guild system. Taylor's scientific management, though widely accepted in the United States after the turn of this century, found difficulty in being accepted in Europe because of the guild tradition of greater stress on "worker arts" and craftsmanship. Some of these differences continue in evidence to this day. For example, in one of the European plants, two Turkish girls had the task of adjusting spin rates on some gyros—they did it by listening to the pitch of the sound.

Many other shop bench practices relied heavily on the craftsmen, thus they were not explicitly defined in a TDP as in US practice. Measures and measurements often had to be tediously derived from functional descriptions. Converting some of the drawings consumed four times more effort than anticipated. No single difference was overpoweringly difficult, but the total resolution of ROLAND's technology transfer demanded more time, money, and skilled manhours than anticipated.

Three of the more obvious differences in practices which were expected to cause trouble proved easiest to resolve: the use of the metric system of measurement, translation from

French/German/English among the participants, and US workers' ability to work from European drawings following the first-angle convention instead of the US practice of third-angle projection. The first angle drawing projection simply presents a drawing with top-bottom, left-right, reversed from the position taught in US schools and from that which a US machine operator expects. Perhaps due to the Hawthorne effect, machine operators proved well able to make the switch. Only one error has been attributed to rubbing the stomach when the operator should have patted his head. (Figure 7)

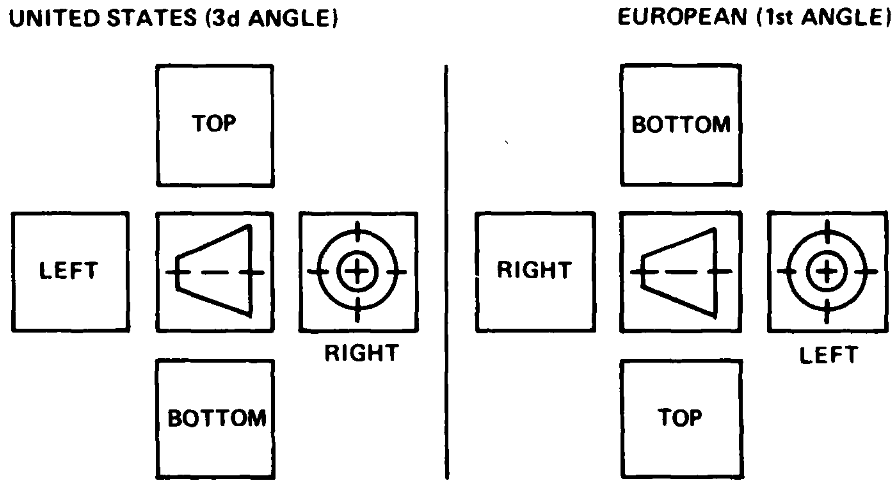

Figure 7. Drawing Projection

To save costs, a decision was made that no metric-to-English conversions would be made and that the metric value, be it dimension, screwhead, or wire gauge, would simply be transferred to the US-qualified drawing. Metrification as a problem proved not to exist and as a concern has largely disappeared. At Hughes, machine tools had been provided digital readouts ($30,000 each) providing choice of English or metric measurements. Neither did metrification prove a problem with the 11,000 or so Hughes/Boeing suppliers.

Language translation, though far from insignificant, was accomplished by applying requisite skills, time, and money. Notes on drawings were translated in-house at the various US plants. Catalogues, manuals, and similar textual material were contracted to Agnew Technical Translations, 1 of only 3 major subcontractors whose purchase orders exceeded $100 thousand. Over 4.2 million technical document words at 6 1/2 cents per word have been

translated by contract to date, some with the aid of automated translation approaches employed by Agnew.[2]

Language Skills. Having grown accustomed to using English from coast to coast, Americans tend to neglect the study of other languages. Indeed, language study is decreasing in the schools at a time when expanding international relationships, such as with NATO, heighten the need for Americans to have foreign language skills. Not only American colleges and universities, but the US Army as well, need to place an increased emphasis on foreign language study. Therefore, some points concerning kinds and levels of requisite language skill are worthy of note.

Engineers and managers travelling to European plants, off the tourist routes, found they required a minimum language capability to get around. Several with college-level French or German, expecting few difficulties with technical language, found instead that they had many problems. Special technical vocabularies had to be developed. A gear case is not a gear box. One or another word sometimes relates to the gears inside as well, but not always. Parallel words linguistically may reflect no more than the draftsman's best guess as to what to name a part he has just designed. To sort out the differences, computer-assisted lists have been developed by Agnew (and others) and system-specific dictionaries are found to be a way of life. Time, trial and error, and money must be applied along with professional-level translator skills. Two translators are assigned to the PM office for general correspondence and intergovernmental reports. Agnew translations employed 4 to 24 translators, depending on workload, who were assisted by people with editing and typing skills.

For multinational meetings, a third-skill level, simultaneous interpretation, is required. As President Carter's experience with a faulty translation during his visit to Poland in 1977 embarrassingly revealed, an interpreter must also be a linguist, and possess the pyschological bent to interpret nuance, pauses, unconnected sentences, and colloquialisms which occur in unrehearsed speech. The total personal and personality involvement requires high skill, a particular psychology, and after a couple of hours, relief. Managers should anticipate the added expense at all three language-skill levels.

Institutional Conflicts. Other social, legal, and institutional differences in societies find their way into technology transfer, for which ROLAND provides some examples.

Form, fit, and function by themselves were not enough to maintain totally interoperable missiles. The same explosive and propellant chemistry would also be required. ROLAND employs tetryl compounds. Stringent Occupational Safety and Health Administration requirements on production of tetryl in the United States caused the United States to discontinue use of tetryl compounds. United States producers of tetryl compounds had either to relearn the requisite processes or ROLAND would have to rely on remaining US stockpiles.

During the technology transfer, a troublesome problem occurred with the radar. To expedite resolution of the difficulty, the PM proposed a joint effort with the European contractors. Although the PM viewed this proposal as a shrewd answer to the problem, the State Department Office of Munitions Control, and some DOD elements, were in agreement that such an exchange would constitute an undesirable export of US technology that was prohibited by law, without specific Department of Defense determination and Department of State approval.[3]

Other events would occur making the joint approach to resolve the radar problem undesirable from the US point of view. First, the French and German Governments wanted the United States to transfer money for the task to them, to, in turn, task Euromissile as prime contractor, and to, in turn, subcontract the task to Hughes. These steps, it would appear, were intended to incorporate the improvement into the proprietary body of ROLAND. Later, Euromissile would propose a price to the French and German governments which the United States would consider excessive.

The point of the foregoing is that in joint efforts such as ROLAND each government is going to work to hold its own technological/marketing advantage through all means available, including controls, unless traditional policy is greatly changed and a new policy implemented.

Similar institutionalized conflicts resided in the audit community, which, under the Armed Services Procurement Regulation, was required to audit and control levels of profit. How does (or should) such authority of a US law extend to companies outside US jurisdiction? Waivers had to be obtained from the usual requirements of the Comptroller General—at no small effort in time and trouble.

As noted earlier, a huge and diversely targeted organization like the US Government takes a long time to change course, especially where major policies are concerned.

ROLAND would find a way to vault all the hurdles, but being first on the track, it had to find out where all the hurdles were.

CHAPTER VII ENDNOTES

1. Howard Chapelle, *The History of the American Sailing Navy* (New York: W. W. Norton & Co., 1949), p. 57ff.

2. Briefing by US ROLAND Configuration Management Office, Mr. Frank Jackson, April 1978.

3. US, Department of State, Office of Munitions Control, Case 121-72, 3 November 1972, and follow-on actions.

CHAPTER VIII

COULD OR SHOULD THE UNITED STATES ADOPT ANOTHER WEAPON VIA THE "TWO-WAY STREET" PAVED (OR BLAZED) BY ROLAND?

Will money, politics, and war again converge in a manner to affect the choice of a weapons system such as ROLAND? In the case of ROLAND there was a recognized need for an all-weather air defense system; however, the military and political preoccupation of the United States with the Vietnam war limited the money available to support further development of MAULER or to develop an alternative all-weather system. But circumstances have subsequently changed—there has been an increase in political attention to the NATO Alliance, an increase in the military threat from Soviet Frontal Aviation, and an increase in the availability of funds since the Vietnam war drew to a close. These circumstances set the stage for the rapid acquisition of an all-weather system. However, there was no serious US systems proponency in the military sphere or in the aerospace industry. ROLAND was available. The doors opened for ROLAND to enter the US acquisition process. It could be argued that ROLAND appeared as an aberration in that process.

But what about the future paths of money, politics, and war?

Money

Did buying ROLAND save money or its proxy, time, as was the initial intent? According to Dr. Robert Roderick, Hughes Aircraft Company's ROLAND manager and Assistant Group Executive, "ROLAND saved more than $500 million in development costs and cut the development period in half."[1] The PM, Brigadier General Ragano, agrees. Estimates from a variety of sources given to the Deputy Chief of Staff for Research, Development, and Acquisition, US Army, range from $400 million to $1.2 billion saved. Weapons proposals resulting from the Field Army Air Defense Study (FAADS) were estimated to cost $5 billion; the ROLAND force will cost about $2 billion. Responses to the RFP, issued in 1970 for the Low Altitude Field Army Air Defense Systems, estimated the development time for such systems to be 11 years. Despite problems, Hughes/Boeing delivered the first ROLAND fire unit and missiles 15 months from the start of fabrication; Hughes/Boeing have made sufficient progress to enable them to complete deliveries within the contract schedule which is 5 years and 6 months from the date of the award of the contract.[2]

Although quantities, characteristics, and inflation make exact comparison of systems impossible, a general comparison suggests at least $500 million and at least several years of time saved. A future, similar project would in all probability achieve the same results.

What about future corporate profits and their relation to local jobs, national politics, and the international policy of the NATO arms market? Bonner Day, Senior Editor of *Air Force Magazine*, writes in the June 1978 issue, "New Threats Confront Aerospace Industry." He was not talking about a new MiG fighter:

> The US aerospace industry, key to military strength and a strong position in foreign trade, is at a major crossroads. . . . America's long dominant position in aircraft production is threatened abroad by government-backed European companies and at home by US government policies. . . . At stake is the future shape of US aerospace, thousands of jobs, and the ability of the industry to respond to the nation's military needs.[3]

An editorial in the May-June 1978 American Defense Preparedness Association magazine, *National Defense*, entitled "A Smaller Piece of the Pie?" summarizes the same concerns, but concludes that ". . . the philosophical objectives of Rationalization, Standardization, and Interoperability are worthwhile and probably essential to the survival of NATO and the Free World."[4] The editor suggests to industry that a willingness to accept less in the way of profits is certain to be the price of continued business.

General T. R. Milton, USAF (Retired), in the January-February issue of *National Defense* notes: "For years the NATO military members have drifted separate ways on equipment and procedures, but the very future of the Alliance may depend on rationalization of collective security."[5]

Robert Basil, representing the Office of the Director of Defense Research and Engineering, at an American Defense Preparedness Association seminar held 4 August 1977 at The National War College, noted:

> I believe, as a cardinal rule, that resurgence of NATO strength must be based upon healthier European national economies and industries, greater European financial commitment to the Alliance, and increased military effectiveness through equipment standardization.[6]

The many threads of contradiction running through these remarks are compounded by the high cost of many of the weapons themselves and the clamor for distribution of the available profits from their production, or at least a trade-off of profits deriving from a mix of high- and low-priced purchases. In testimony before the Senate Armed Services Committee, Mr. Carl Damm, of Germany, and Mr. Phillip Goodhart, of the United Kingdom, both parliamentarians representing their respective governments in the North Atlantic Assembly's Subcommittee on European Defense Cooperation, discussed a trade-off. They suggested that their countries could jointly purchase AWACS, whose unit cost would be too expensive if only a single nation bought it, provided that the United States could buy German or British weapons of similar total costs.[7] Would the United States buy a ROLAND in such a package? Maybe yes, maybe no.

Other contradictions and resultant confusion spring from the shift in politico-economics of the Trilateral States—the United States, Western Europe, and Japan. This incompletely understood, still evolving process has created many divisions among those concerned with the assessment of world strategy. Illustrative of these divisions are the sharply differing responses to Presidential Memorandum PRM-10 which assessed the convolutions of world strategy as viewed by the new Carter administration.

Bonner Day's article perhaps contains the answer to the dilemma of shrinking profits in the new world order. In each case he cites to illustrate a challenge to US aircraft producers, international consortia are involved. The A300 finds Aerospatiale and Deutsche Airbus linked; the European transport aircraft of the 1980's assembles Aerospatiale, British Aerospace, Fokker VFW of Holland, and MBB. High cost and technical complexity, among other factors, are reflected in this trend to consortia-produced systems which includes weaponry. From the point of view of politico-economics, the rationalization of collective security is being shaped by events, and not vice versa. For example, NATO standardization by the working of market forces was excluded by the terms of the European Economic Community treaty for political reasons, but is now being driven by financial considerations and the demands of military technology. From the point of view of individual firms, as Bonner Day expressed it, "we must either share contracts and jobs or risk losing the whole contract and all the jobs."[8]

Although sales, not royalties, comprise the complete meaning of "two-way street," ROLAND provided an infusion of licensing fees which Euromissile needed. ROLAND's production in the United States provided a share of jobs and profits, too, and furthered NATO standardization. Looking at what profit can come from the marketplace, competitive international R&D and licensed coproduction, as was the experience with ROLAND, seems an all-around best approach, by default, if for no other reason.

Politics

Bonner Day's article spotlights the concern of US corporations that they cannot successfully compete with European companies backed by favorable financing arranged by their governments. United States corporations find themselves caught in a vacuum between foreign technical competition, with foreign government backing on the one hand, and a lack of US political interest in doing the same on the other. A severe challenge to the accustomed US Armed Forces combat developments/source selection process would occur should consideration of favorable foreign government financing of US weapons purchases play a strong role in a future ROLAND-type competition. Could it, at this turn of the political tide?

Excessive political pressure in the opposite direction, that is, favoring US makers, could lead to an equally serious, but different challenge, to the combat developments/source selection process. When a ROLAND-type weapon was first being considered in the late 1960's and early 1970's, a popular concept which favored buying US and factored heavily against buying European was the "1/2 generation lead," expressed by Dave Haebner, of the Office of the Director of Defense Research and Engineering, at an American Defense Preparedness Association seminar in May 1974:

> Any proposed foreign system, however well demonstrated or matured, must compete against unproven but passionately supported domestic proposals. In all cases the level of technology employed in the competing (US) proposals will be more advanced than that used in the foreign hardware and is, therefore, a half generation ahead.[9]

That was 1974. Political pressure might heavily favor US producers in a multinational source selection such as ROLAND if, for example, severe domestic economic conditions were to occur. Such a policy might force the Army to accept a package of promises between glossy

covers, or equipment less effective than the weaponry Europe is today capable of producing. Such a policy may suffice for a member of a coalition, but not for a superpower.

Politics is in many ways caught in the middle between money and war, and faces a limited number of open avenues. In seeking a political route to improve NATO standardization, several political, politico-military, and politico-bureaucratic initiatives have been taken which some view as imperiling US corporate profits on the one hand and military technology on the other. In the face of these potential entanglements, the multinational competition that led to selecting ROLAND scores well, again, in assuring the best technology for the Army.

Ambassador Robert Komer, adviser to the Secretary of Defense on NATO matters, in testimony 14 June 1978, before the newly formed Special Subcommittee on NATO Standardization, Interoperability, and Readiness of the House of Representatives—the subcommittee's formation itself symbolic of NATO standardization's political momentum—outlined the new efforts of the Carter administration. The Ambassador noted that Allied acceptance of the Long Term Defense Program (LTDP) at the NATO summit in May 1978 had underscored President Carter's leadership in NATO. Further, he outlined measures contained in DOD Directive 2010.6 (March 1977), which would give weight to Rationalization, Standardization, and Interoperability when weapons proposals were being reviewed in the Defense Systems Acquisition Review Council (DSARC). Ambassador Komer then reviewed 15 major programs contained in annexes to the LTDP which are intended to be cooperatively developed. These include common families of new antiarmor weapons, common air-to-surface weapons, common lightweight torpedoes, and so on. It is intended to assign a nation to "take the lead" in developing each element of a package.

As for the politico-bureaucratic and politico-military initiatives, according to Ambassador Komer, NATO will develop a framework "for harmonizing tactical concepts and for identifying and analyzing alliance mission needs," the latter extending typical US use of Mission Element Need Statements (MENS), nee Required Operational Capability (ROC), nee Qualitative Materiel Requirement (QMR), nee Military Characteristics (MC), to run a source selection on an international basis. Such international documentation of military needs does have a precedent. In 1959 NATO adopted the NATO Basic Military Requirement (NBMR) procedures to drive

decisions about weapons. Approximately 50 NBMR were agreed upon, but only seven were fully or partially met with equipment already in existence. None led to cooperative development and coproduction.[10] Of course, the politico-economic environment was then quite different.

Both the lead nation approach and the NATO MENS approach raise hackles and ire in a variety of audiences. Neither the lead nation research and development approach nor the MENS international combat developnent approach match the ROLAND experience. The lead nation approach invites assignment of tasks based on political weight rather than technological capability. The MENS system simply extends previous similar efforts toward NATO RSI, reaffirming the familiar constraint of bureaucratic solutions, which is the repetition of what is already familiar. Neither approach addresses the lessons learned from ROLAND or sets policies that are needed to improve the process laid down by the still operative Packard memorandum of 1971, which encourages licensing among corporations and competition among the resulting teams. Each approach warrants discussion, in turn, considering the interaction of politics and technology, to see if a ROLAND could or would emerge.

First, consider the combat development/research and development aspects together. An example of prior experience lies in the efforts of the British Admiralty and Parliament to inject standardization into their ship construction programs two centuries ago. RSI is not new. The problems were the same; they even had the same scandals. Politics and technology in this case clashed to produce weaponry a half generation behind the times.

Howard Chapelle, naval historian, provides a synopsis of what happened:

> The histories of maritime nations show periods when all the factors necessary for improvement in shipbuilding and design come into being and a nation's naval power and maritime interest reaches a zenith. . . .
>
> The 18th century opened with Great Britain in possession of about one-third of the whole of Europe's naval power. The French had begun to improve their ships markedly. . . . They began a study of hull form and searched for improved construction methods. While aware of this, the British tried to find means to economize. . . .

This led to fixing the dimensions of each rate at a minimum thought practical in peacetime, to be modified as required with the passage of time. . . .

The results of the peacetime standardization represented in the "establishment" (classes of ships; lst rate, 2d rate and so on by guns, length, sail) were the same as much of the military and naval standardization of more recent times. Designs for new ships and equipment became obsolete but remained in use until . . . replaced at great cost by the free development forced by wartime competition with an active and enterprising enemy. . . .

Ships were small for the number of guns they carried and so were slower and less powerful than the larger vessels used in continental navies. The sense of power that sprung from the possession of the biggest navy in the world and the satisfaction of victories achieved by a well-manned naval service, combined with the effects of the "establishment," led to a slowing down in the British efforts to improve. . . . From late in the 17th century to the American Revolution, the French gradually took the lead in quality of ship design.[11]

War

These standardization efforts were soon tested in a war between England and France. Fortunately for England, Napoleon, an artillery officer, could not quite figure out what to do with a navy. In an incredible combination of events, the French fleet slipped out of Admiral Nelson's blockade in Southern France, and sailed to the Caribbean. Nelson, in complete violation of orders to withdraw to the English Channel, instead chased the French all the way across the Atlantic, and all the way back, then by superior tactical skill and at the cost of his own life defeated the French Fleet off Trafalgar. His fortunate victory does not explain why the Royal Navy ships lagged a half generation behind, nor should such good luck invite the United States to allow a half-generation lag in weaponry to occur.

Consider the combat development process—NATO MENS—in the light of historic precedent. Would such a development effort also contribute to a half-generation lag? Imposing the NATO MENS procedures will add yet another management level within which a system proponency must secure agreement. Another such step must take more time. According to Brigadier General Ragano, in the United States "under the less complex procurement organization of the separate Technical Services, the Ordnance Corps fielded the NIKE and HAWK systems in 4 1/2 to 5 years." This is not to say the systems

were fielded complete with a full complement of logistic particulars, but nevertheless they moved from research laboratories into the hands of the troops within those short time spans. Although it is granted that the increasing complexity of weapon systems bridging Technical Service lines, in part, forced the services' amalgamation, General Ragano points out that 10 to 11 years are now consumed in getting weapons from the concept stage into the field.

Critics of ROLAND bemuse the fact that "it's 1960's technology." To superimpose yet another level on that of the Army Materiel Command, OSD, an enlarged and involved congressional staff, and now NATO—all in the interests of better management—can only compound the problem. The inevitable delay, or a decision to compromise requirements in the interests of securing agreement in the formulation phase, could result in a weapon a half generation behind what an uninhibited NATO producer could develop, or worse, a half generation behind what a Soviet Design Bureau could deliver. Bob Basil noted in remarks at The National War College that securing NATO European participation in standardization is now a cardinal rule. When cardinal rules of policy become ordinal steps of implementation, each step and each layer must be counted.

Hobson's Choice

Within the organizational dynamics of a more rigorous NATO-wide combat development process, the dilemma may arise of either accepting a weapon a "half generation behind" or of bypassing the MENS system. Deciding when and how to bypass the formal combat development process is difficult enough within one army; the decision takes on serious political and economic overtones in an expanded international arena. Forcing the decision from the bureaucratic to the political level may break the logjam; but, at the political level, the technical consequences of such decisions are not well understood.

To reach agreement on military requirements seems to be an easy problem, but it is not. There are many different perceptions of threat, the consideration of which for ROLAND alone entailed several years of work in an international element of the Joint ROLAND Central Committee. Further, different armies subscribe to different tactical and doctrinal philosophies for countering the same threat. For example, differences in Electronic Counter Counter Measures (ECCM) tactical approaches in US and German ROLAND tactical employment resulted in a divergence in US and Euromissile radar transmitter designs.

Still other differences complicate the problem of defining requirements. Deeply ingrained military traditions shape differing concepts of tactics and consequently weapons design. The British view a tank as a moving pillbox—with the formulation of that perception apparently going back to the Battle of Hastings. The Soviets view a tank as a Mongolian pony—small and fast and carrying a bowman capable of firing and reloading on the move. Due to the technological edge derived from the Mongolian hordes' invention of the stirrup, their horsemen could fire on the move, but their enemies could not. Soviet tacticians drilled firing on the move into the crews of World War II T-34's, designed the capability into the T-54/55 in the mid-1950's with rudimentary gun stabilization systems, and continue both the design and tactical doctrine today with the small T-72, equipped with automatic loader and stabilized gun. The US Army never adopted similar tactics or the design until recently, and now views the role of tanks somewhere between the cited extremes.

Within individual armies possessing strong military-industrial relationships and elaborate means for expressing requirements, there are incoherencies between research and development, on the one hand, and the search for tactics and doctrine on the other. For example, although during the ROLAND development process those involved seemed to be continually arguing the existence or fiction of an all-weather (or most-weather) technical requirement, both Colonel-General Levchenko, Chief of the Soviet Army's Air Defense Branch, PVO SV, and Major General John Koehler, Jr., Commandant of the US Army Air Defense School, stressed mobility, not all-weather capability, as the first priority—the former in his article in the 1976 *Soviet Military Encyclopedia*, the latter at the ROLAND Executive Review in early 1978.

It is interesting to note that the only thing that moved in the OR/SA studies supporting the Short Range Air Defense Study were

the airplanes; nor was mobility a key element of the RFP which was written apparently to accommodate the mobility already designed into the competing systems. It would be interesting to see the corresponding studies and documents leading to the Soviets' amphibious SA-8. Did the Soviet Army bypass their own process for developing doctrine, in order to develop mobile systems, or did the process support the mobility designed into SA-8. Did the US Army bypass the process by stressing single-vehicle mobility in source selection, or was the process simply unable to articulate air-defense mobility in an RFP or operations research study?

The creation of a regimen of NATO MENS to develop NATO military requirements is a policy that certainly deserves to be tried. However, the implementation of any such effort must avoid being hoisted on its own petard, while trying to open the gates to NATO standardization. In purest form the NATO MENS approach would undoubtedly result in a source selection process different from that used for ROLAND—one which is more traditional to US RFP practice, but one which is longer.

The Technological Edge

As noted, assigning a "lead" country within the various weapons families could result in a half generation lag, or more, if assignment is made on the basis of political importance rather than technological excellence. The politico-military nature of the various councils which would implement a policy of assigning weapons development to nations certainly, and unavoidably, contains all the ingredients to err, just as did the British Admiralty and Parliament in the case of naval vessels in the age of Nelson. If "leads" are established on a political basis, then US companies are going to team with European companies on the basis of who they think will win the political competition. Dr. Malcolm Currie, former Director of Defense Research and Engineering, among others, believes such a set of circumstances would destroy the technological edge of US industries within the decade.[12]

How fragile is the US technological lead? Are the European transport aircraft Bonner Day discusses going to be bought, on the premise that US airlines must accept less than the optimum technology because it is affordable? Is it a coincidence that measures to restrict technology export (as was evident in the ROLAND PM's attempt at a joint resolution of the radar problem) were included in the deliberations of a 15-member committee appointed by President

Carter to study slipping US technological superiority in many defense and nondefense areas? Is the intent, perhaps, to preserve what we have by extending export controls?[13] Is it a coincidence that Dr. Samuel Huntington, an advisor to National Security Advisor Brzezinski, in a speech before a seminar of businessmen, academics, and government leaders at West Point concerning integrating national security and trade policy, could propose controlling nondefense exports to the USSR to exact political or military concessions? This would be a major departure from prior export control policies.[14] Viewed in a broader sense, are export controls an offensive card in the balance of power, or are they a defensive card to protect a deteriorating technological lead? Or, are they an invisible card which is not playable at all?

When the focus shifts from the intra-Alliance arms market to the intercoalition correlation of forces, the significance of a technological lead, however fragile, becomes starkly clear. Economically the West remains superior. However, the Soviet command economy can be expected to allocate to armaments whatever share of the gross national product the military believes it needs. Politically, the defeat of the Communists at the French polls early in 1978, and the apparent aversion to the Red Brigade's murder of Aldo Moro in Italy may be setbacks, but these episodes will soon be forgotten by party visionaries who also tend to forget the Soviet invasion of three of its own "fraternal" allies. In fact, the Soviets deny any connection with Italy's Red Brigade. A 25 May 1978 issue of *Pravda,* for example, carries a cartoon depicting a column of gun- and bomb-carrying terrorists, all followed by a cigar-smoking capitalist carrying fistfuls of dollars. In any case, increasing domestic Communist pressure to restrain their governments' further commitment to the Alliance can be expected.

Militarily, the nuclear balance is considered roughly equivalent. As for the conventional balance, nobody knows for sure. The US Army, however, publishing the first revision, in almost a decade, to its basic doctrinal tome, FM 100-5, takes the startling, but accurate, position that we must be prepared to fight—and win—outnumbered. Only superior soldiers, superior tactics, and superior technology can carry out such a bold doctrinal precept.

When viewed in this context, preserving what technological edge the West collectively, and the United States particularly, possesses assumes critical importance. Competitive R&D, according to most voices, is the only way to achieve that end. Consequently, the

answer to, "Should the ROLAND selection experience be repeated?" appears to be yes. The answer to, "Should we assign a weapons 'lead' politically?" appears to be no.

What Is To Be Done?

Again quoting Robert Basil, who, at the August 1977 seminar, addressed the policies of Rationalization, Standardization, and Interoperability, the competitive edge, and the technological edge:

> The challenge is the recognition of adapting to a changing world in a way most constructive to the United States, both militarily and industrially.
>
> Is *reality* our stable in-house R&D establishments with solid continuity, in a strong partnership with the innovators and builders in industry, who together have met every challenge called upon it in the past 25 years with peerless weapons solutions for our forces?
>
> Or, is reality old-line, in-house establishments with their incestuous satellites of contractors, together resisting any change to existing relationships, and protected from more efficient foreign competitors by a dubious set of source selection values?[15]

The protectionism to which Robert Basil refers, and the vision of export controls, provide a background against which the advisability of political assignment of weapons development must be evaluated. Protectionism, controls, and political assignments in concert would greatly damage the competitive technological edge, whereas the kind of competition held for ROLAND again stands out as a favorable alternative. Would any contender have been as good without the competition from the others?

As a corollary, whereas many businessmen formerly felt in a vacuum because of the US Government's political choice not to act as drummer for external sales as do other governments, they now feel in a squeeze between foreign competition and the US Government's policy of seeming extension of export controls. Perhaps a better policy than lead nation assignment and export control would be to invest in advancing research and development. In such an enhanced research environment, the response to the question whether there should be another ROLAND-type source selection, again, appears to be yes. The problem for MENS and "lead nation" policies to solve,

then, seems to be to find a way to assure the competition that will also drive technological development and lower costs.

ROLAND and the Packard Memorandum

Finally, neither the lead nation policy nor MENS comes to grips with the lessons learned from the ROLAND experience. The Packard memorandum is still open. Competitive R&D with licensed coproduction, accepted as a policy of DOD, was endorsed by congressional legislation in 1976. For the systems coming into the forefront, no one's power of prevision is perfect, and institutional memory is short, so some policies and guidelines are in order. Initially, the 1971 Packard memorandum encouraging licensing between contractors may require some revision. Research indicated that, in part, at least, the policy was launched by OSD and congressional elements as a way to bypass the barrier against European procurement presented by the service bureaucracies in the procurement and doctrinal arenas. ROLAND broke the logjam and resulted in an excellent weapon—when the shouting died down and people were able to get to work. Policies to smooth the road are simple to identify but may be difficult to achieve.

The US Government must state what conditions constitute an acceptable license agreement. What fees, payment schedules, rights in data, and conditions for third country sales can be allowed? Or, perhaps a better and less restrictive way—what license conditions will be disallowed? There were nine changes made to the agreed Euromissile/Hughes/Boeing license agreement: eight at the behest of the US Government, only one by Euromissile, a simple request to change correspondent banks. Although the changes were eventually made, none came free. Setting conditions ahead of time will delimit the eventual costs and defuse the misunderstandings which do not promote standardization or the Alliance. Intergovernmental Memorandums of Understanding may prove the best first step in lieu of intercorporate licenses.

Next, for each project, the level of "standardization" should be agreed upon in advance. Once the choice is made, as with ROLAND's "form, fit, and function," engineering will determine the eventual product. The mid-course redirection of the ROLAND project was astonishing, and seemed to derive from two sources.

First, the letter from Senator McIntyre did not want to give any appearance of congressional meddling with the source selection

process while it was underway. Consequently, there was great surprise in receiving the Senator's redirection a month after contract award. The rationale for the delay was a good one. It is deserving of note that everyone interviewed during this research gave the Army's source selection process high marks for fairness, honesty, and the ability to get the best weapon for the field—whether they favored the actual choice or not. Such unanimity is rare and warrants preservation.

The second source of the midcourse correction to achieve interchangeability should have been better managed. No large organization—and the US Government certainly qualifies as such—can make strong shifts in policy and see the policies implemented without first actively promulgating the new policies. The November 1975 DOD Memorandum on RSI and the amendments to the appropriation bills came too late for the early converts in the ROLAND Project Office. Most people at the working level would never be aware of them, and would pursue the policies they already understood and doubtlessly wished to continue to support. An example of the dynamics of bureaucracies is that in proceeding from RFP to contract award, the already vaguely worded passages requiring standardization lost some, or all, of their precision. Another example is the denial of export authority for technology to be developed in the joint Hughes/Euromissile effort to solve the radar problem which was proposed as the most cost-effective approach. Many more examples derive from the Armed Service Procurement Regulation, laws, rules, regulations, standards, and practices among the procurement and auditing communities. The examples given need to be examined, and policies established, for waiving or altering some of their provisions to fit international projects. This study has made no attempt to be exhaustive in this regard and the requirement stands, regardless of which route is taken in future international weapons acquisition. New policies in a complex society require sufficiently strong promulgation to acquire constituencies, as well as prescribe rules, and thus require time.

Throughout the interviews and the ADPA seminar discussions many people murmured about a new cult—RSI—emerging to standardize for the sake of standardization. Indeed, the necessary system is being formed—congressional committees, councils within DOD, shiboleths to which weapons proponents must genuflect in the weapons acquisition process, and the formalization of procedures via MENS and "lead nations" in the weapons families. Time and again, senior people advised caution: to move carefully, to achieve RSI on a

case-by-case basis as the opportunity occurred, and not to try to accomplish everything at once. ROLAND, the F-16, and the HAWK all achieved one or another success opportunistically. The ethos of the huge coalition-wide agglomeration of money, politics, and war favors the case-by-case approach, recognizing a monopoly on neither good ideas nor bad ones.

The Verdict

In answering the question, "Could or should another weapon be acquired as was ROLAND," evidence clearly seems to favor "Yes, it should." Money was saved, time was saved, profits were earned, and much needed weaponry is coming into the hands of the troops.

Answering, "Could it occur," depends on policy which has again changed to bring in the MENS and lead nation approaches, leaving the Packard memorandum of 1971 by the wayside. Answering the question of "could" must await the transformation of these currently evolving redirections as they move from the temples of policy formulation to the school of hard knocks of policy implementation.

CHAPTER VIII ENDNOTES

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3. Bonner Day, "New Threats Confront Aerospace Industry," *Air Force Magazine,* June 1978, p. 70.

4. Editorial, *National Defense* (ADPA), May-June 1978, p. 526.

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6. Robert A. Basil, speech before ADPA seminar, 4 August 1977. Mr. Basil was then Assistant Director of International Programs, ODDR&E, OSD.

7. US, Congress, Senate, Committee on Armed Services, *Hearings before Subcommittee on Research and Development,* 31 March 1976 (Washington, DC: Government Printing Office, 1976), p. 7ff.

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10. Congressional Research Service, "NATO Standardization: Political, Economic, and Military Issues for Congress" (Washington, DC: Government Printing Office, 1977), p. 11.

11. Howard Chapelle, *History of the American Sailing Navy* (New York: W. W. Norton Co., Inc., 1949), p. 9ff.

12. Malcolm Currie, Hughes Aircraft Company, formerly DDR&E, telephone interview, May 1978.

13. Thomas O'Toole, "Decline in US Technological Superiority Studies," *Washington Post*, 21 June 1975, p. A15.

14. Fred Barbash, "US Export Licenses are Linked to Soviet Cooperation," *Washington Post*, 26 June 1977, p. A5.

15. Basil, speech, 4 August 1977.

CHAPTER IX

A HISTORICAL RETROSPECT

This monograph highlighted some organizational trends and proclivities which most experienced corporate and military managers understand. Nevertheless, using only the single example of ROLAND, it is difficult to establish these trends as permanently operating factors. A consultant to this effort remarked that if such "rules" are indeed "rules," they must be transferable. Could a second example of trials and tribulations with Rationalization, Standardization, and Interoperability be found which would support the author's contention that such deterministic rules exist, and that ROLAND's experience is replicable, thereby making the orbits traced by that nebulous system of "rules" more clear? Early examples of attempts at standardization in shipbuilding were used in this study to underscore the constancy of the human problems standardization entails. But the management or technology of constructing sailing men-of-war differs too much from today's technological environment to be useful, beyond making that point.

Problems similar to ROLAND's in exchanging Technical Data Packages from plant to plant and from industry to industry (airframe to automotive) during World War II are extensively documented.[1] However, these examples (notably Boeing's B-29 and B-24) did not entail the national political controversies or the international politico-economic entanglements of ROLAND.

As research demonstrated, ROLAND did indeed have an international precursor and a famous one at that. The story provides valuable insights into the business of international standardization in military affairs, and supports the theory that there are indeed predictable rules and patterns in technology transfer across the full spectrum of determining military requirements and meeting technical specifications.

As the industrialized world entered the 20th century, the technology of ordnance design had developed to such an extent that most advanced countries approached about 3 inches as the optimum caliber for light artillery: the English, 3.3 inches; the Americans, 3 inches; the Germans, 77 millimeters; and the Italians, along with the French, 75 millimeters.[2] The size of a 75 mm or 3-inch piece matched what 6 horses could pull over rough terrain, and men could handle in a firing position. Of all these weapons, the "French 75" gained universal

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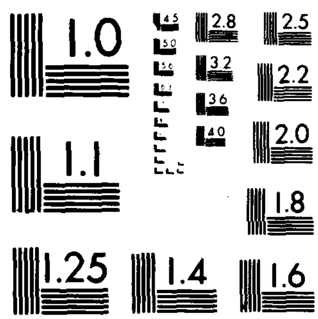

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

fame, capturing the imagination of the world in saving Paris from the relentless blows of the Schlieffen plan, a plan which in execution in 1914 hurled a lightning strike at the heart of France.

As the clouds of the Great War cast their shadows across the Atlantic to the United States, drawing America ever deeper into the coalition of England, France, and Italy, the American Army faced a desperate shortage of light artillery. Of all the supply shortages, light artillery presented the most difficult to resolve, because of long lead times and the demands of precision manufacturing. As events unfolded, it was decided by the coalition that the American forces would fight together with the French, and that US and British light artillery would adopt the French and Italian 75 mm caliber. These decisions destined the United States to transfer the technology of the French 75 mm field pieces and to manufacture the gun and its ammunition in this country. This production project would eventually become a monumental effort.[3]

Watching the war spread from Sarajevo across Europe, the still neutral United States, although having a new 3-inch artillery gun under development, found itself possessed of scant few pieces, a hodge-podge of calibers, and an artillery manufacturing, support, and supply ability that remained chaotic or nonexistent:

> Almost from the outbreak of the war in August 1914, (the United States) succeeded in placing observers with the various armies in the field (whose) reports . . . were filled with data showing the deficiencies of our own military organization for war on a modern scale . . . but the reports were filed away in the archives of the War College to gather dust of official neglect.[4]

Attache reports from Europe were likewise numerous, but comprised verbose general observations containing little specific technical information upon which to base weaponization plans.[5]

Brigadier General William Crozier, Chief of Ordnance, sent Major T. L. Hillman to England and France to examine and purchase plans and specifications of European artillery to assist in formulating our own designs. The necessity for speed was urgent. In 1911, the Army Staff estimated requirements for artillery based on equipping a force with 3.16 guns per thousand men; this was later revised to 4.9 guns per thousand men—in a million-man force, the planning for which was soon to begin.[6]

Crozier and Hillman were exceptionally qualified men for the job. The brilliant Brigadier General Crozier was appointed Chief of Ordnance in 1901, as a captain, prior to many senior officers; he was promoted to Major General in July 1918. Hillman was later to command Rock Island Arsenal, which continues to serve the mission of artillery design and development for the US Army. When Major Hillman reached England, the Ministry of Munitions provided drawings of all types of ordnance. Armstrong-Vickers wanted to sell him designs for heavy howitzers, and War Office approval was obtained. But the British Foreign Office refused to sanction the transfer. The French Government at first refused even to receive the American major. Never mind the long lead times of artillery production. The United States was not legally a belligerent.[7]

But the transfer would eventually take place. While Major Hillman was conferring in Paris with officers of the Bureau of Exterior Operations of the French General Staff, the United States declared war.[8]

No sooner had the United States committed itself to the war, than the congruence of money, politics, and war immediately resulted in a melee of competing objectives. The situation was exacerbated by the mobilization of US industry to produce a tenfold increase in the numbers of guns, a 47,000 percent increase in machinegun ammunition, and a 180,000 percent increase in artillery ammunition over peacetime requirements.[9]

The immediacy of war took precedence over money and politics as the struggling Allies searched for the fastest way to get the American troops equipped and into the trenches. The French Government proposed standardization of light artillery calibers, and offered an inducement to fit their proposal—France would supply five of their incomparable 75mm field guns per day to arriving American forces, beginning August 1917,[10] while US industry tooled up.

Some extracts of a French press release by the High Commissioner, G. Andre Tardieu, issued in Washington on Bastille Day, capture the mix of money, politics, and war on the international level, and the enthusiasm of the moment:

Washington, 14 Julliet, 1917

Presidence Conseil
Copie a Guerre-Armament

An important agreement has been concluded between the *United States Government and the French* . . . characterized by two ideas. On the one hand the American Government wished to adopt the quickest solution in order to realize in the shortest time the complete armament of its forces. On the other, with great foresight, they attached particular importance to realizing, for the American and French armies, called to fight on the same battlefields, uniformity of munitions, of such capital importance from a tactical point of view.

The double certainty of rapid production and uniformity of munitions, decided the United States Government, despite the incontestable value of its own materiel, especially that of the three-inch field gun, of which the superior qualities are universally recognized, to adopt our 75.

From the military point of view, it is evident that uniformity of type of guns and munitions for armies fighting on the same battlefields, is an appreciable guarantee of safety and efficiency. The supply and volume of fire are thereby equally facilitated. Unity results spontaneously from identity of weapons. Finally, all tactical results, obtained by the experience of three years of war, are, without previous adaptation, assimilated by the American Army.

From the industrial viewpoint, the unity of effort created between the manufacturing plants of the two countries, will produce happy results without precedent, not only during the war, but also subsequently. Common action provides the best means of mutual acquaintance and for preparation of the close cooperation which it is desired to organize for the future.

From the financial standpoint it is possible to hope that the purchase by the United States of French artillery materiel will create an improvement in exchange, which under the existing relations of America and her European allies, is as much to be desired by the *United States as by France.*

It is also likely that the adoption of the metric system, which has been officially requested by the American Bureau of Standards and which is much to be desired from the point of view of future Franco-American interests, may be thereby facilitated.[11]

Such unbounded, if ungrammatic, enthusiasm was not universally shared in the US War Department. Although Major General Leonard Wood, Chief of Staff, strongly supported the "suggestion" to adopt British or French calibers, the Chief of Ordnance and the War College Division (formed to assist a much

constrained General Staff to plan for the war) opposed the idea. A War College Division memorandum to the Chief of Staff dated 12 May 1917 states:

> Dependence upon another nation for our arms and ammunition is contrary to the independent spirit of our people. It is thought that the abandonment of our arms for inferior arms of another nation would be resented by the public at large, and satisfactory explanation by the War Department would be difficult.[12]

How a nation with such a meager military production base at the time could boast of superior arms production abilities was not an apparent consideration.

At the national level, the *differing roles of armed forces* and their legislatures at differing epochs and against differing socio-political backgrounds present a curious mix.

In France, according to one General Gascoin, Commandant of Artillery, Ist Corps, writing in *L'Evolution de 1'Artillerie Pendant la Guerre*, the French Parliament, encouraged by a few officers who held a clearer view of emerging tactics and doctrine, took the lead in *appropriating funds for procuring* guns, over objections of many officers who, promulgating official French Army doctrine, did not perceive the coming war as a war of artillery, but focused instead on the infantry battles of 187O:

> In reality, if it is true that we had not sufficiently developed heavy artillery, it is not less true that the Germans had excessively neglected their light artillery. This advantageous situation as to our field artillery is, and let us say it quite loudly, completely to the honor of the French *Parliament, which voted, at the* beginning of 1909, the law for the enormous augmentation of the field artillery, an augmentation of 50 percent in the number of regiments, and that despite the advice of a large number of unit officers or staff officers of all arms who had not completely understood the importance that materiel, artillery, and machinery must inevitably assume in the modern war.[13]

In the United States the position of the legislature, or for that matter, the executive branch, vis-a-vis the Army was reversed.

In 1906, an appropriation requested by General Crozier of $1,200,000 for artillery was halved by the Secretary of War to $600 thousand and again halved by the House of Representatives to $310

thousand, a level which would produce 11 batteries a year and deliver the total planned procurement, should war occur, not sooner than 1923. Immediately upon declaration of war in April 1917, Congress appropriated $171,900,000, then in October, another $225 million.[14] But General Crozier would later bear the brunt of bitter criticism for lack of preparedness despite having been denied funds, for lengthy development times after being given the funds, and for procuring French-produced weaponry instead of US guns in the interval.

Many in Congress were totally chagrined that "our boys" had to fight with foreign weapons, that US industry was unable to produce when called upon, and that "poor bleeding France" had to bear the industrial load, and so stated vehemently in committee deliberations and public speeches. Some accused the French of bribing us to enter the war by the political means of offering military aid. Times change. Quite a different politico-economic milieu exists today in NATO RSI, but the players remain the same as do the equally appositive factions.[15]

To prevent the financial side of the triangle from producing adverse effects, Crozier instituted cost-plus-fixed-fee and cost-plus-percentage-fee contracts,[16] as a way of reducing corporate risk and ameliorating the effects of the war's high inflation rate on accustomed fixed-price contracts.

The military requirements side of the triangle presented difficulties with the technology transfer, with production, and with proponents of US systems. Intensified by divergent, institutional factors, the difficulties converged on the French 75, as if through some mystic prescience, ROLAND were being used as a roadmap.

The US field artillery standard light piece at the time was the 3-inch model 1902. The 3-inch Model 1916 was well underway and, in fact, 35 had been already produced when the decision was made that the American Expeditionary Force would fight alongside the French, and that the 75 mm would be adopted as standard throughout the coalition. Orders were given to rebore the Model 1916 guns already produced so as to accept the 75 mm ammunition. Similar modifications were ordered for the British 18-pounders in production at Bethlehem Steel Company. Subsequently, US manufacturing would follow the French 75 designs.[17] The Allies were launched on one of the most successful, yet traumatic, efforts toward weapons standardization, ever attempted.

What was the magic of the French 75 which raised such enthusiasm, even earning the dubious distinction of having a cocktail punch named in its honor?[18]

The French 75, specifically the Puteaux Arsenal Model 1897 75 mm field gun, represented a quantum jump in artillery technology which significantly transformed tactics, techniques, and manufacturing standards for light field pieces. The United States, England, France, Italy, and Germany, all struggled to keep their technological edge. Many technological breakthroughs in obturation, propellant chemistry, and manufacturing technique contributed to the excellence of the French 75. Its key secret, however, lay in the new invention of light caliber recoil mechanisms. The ability of the piece to recoil without moving the carriage, and to return to battery with the gunner still hovering over his sight, permitted rates of fire of artillery to soar from one round per minute to more than twenty.[19] At the same time, because the gun remained in place, it could be aimed at an aiming stake, and by using calibrated traverse and elevation mechanisms, could be fired at any point within range by calculating the required offset using trigonometry and range tables. The tactics of indirect fire, and massing of many batteries in a quick-fire barrage, totally changed light artillery tactics and doctrine, from the previous belch of flame and whiff of grape fired toe-to-toe with infantry.

The US Army was also engaged in developing the new artillery tactical concepts within its own small Ordnance Department. At the outbreak of war, the department was arranged in divisions: a Gun Division for cannon and ammunition, a Carriage Division for artillery carriages, and a Small Arms Division, among others.[20] A rearrangement to a functionalized organization, resulting in the Design Division-Procurement Division separation, was to occur 9 months into the war, forced no doubt by the frenzied pace of mobilization.[21]

Although the Ordnance Department returned to its original structure shortly thereafter, the agglomeration around commodities or commodity groups and the division along lines of R&D, procurement, and field service continues to serve in one form or another as the structural basis of organization to the present time.

In 1911 the Carriage Division had developed a new carriage, incorporated into the Model 1916 3-inch gun which was the model in production when the decision was made to adopt the French weapon,

specifically the Puteux Model 1897. Range as well as rate of fire ruled who won or lost the artillery battle, and range was a function of elevation as well as muzzle velocity. The French Model 1897 was mounted on a conventional single-trail carriage, limiting elevation to 19 degrees. The US Model 1916 carriage with its new split trail afforded 53 degrees of elevation and greatly improved traverse limits as well. The split trail carriage enjoyed enthusiastic support by the Field Artillery Board. United States officials decided to adopt the metric French 75 mm caliber gun, but to mount it on the M1916 carriage, thus putting US artillery at least a half generation ahead of where it had been. Orders for the carriage were placed with Rock Island Arsenal, Bethlehem Steel, New York Air Brake, and Willys Overland for M1916 carriages, while immediate needs were filled by purchasing the Model 1897 from France.[22] But producing the M1916 carriage proved more difficult than expected. When the specter of delayed deliveries became clear, the Ordnance Department, with General Pershing personally urging the change, decided to transfer the technology of the entire French Puteux Model 1897, including its unit trail carriage,[23] and build it in the United States.

But what had been agreed upon politically proved not so acceptable bureaucratically. Although at the time of our entry into the war the French Government agreed to reveal to us the enormous amount of information which would be required for the manufacture of these weapons, the Puteux Arsenal was loathe to surrender their recuperator's secrets which they believed the Germans incapable of duplicating, despite the Germans having captured plenty of samples. In France, parts of the recuperator were produced in several different plants and assembled in secure rooms at the Puteux Arsenal to which only a few people were authorized entry. Major Hillman was told that release of the documents would not be possible. Not until 11 August 1917 were the secret drawings of the M1897 carriage and its recuperator finally received and complete specifications and data were not exchanged until April 1918, 7 months after US troops entered the trenches.[24] The lack of complete information seriously handicapped negotiation of contracts and manufacture. It takes time for high governmental decisions to filter to the field.

Concurrently, efforts to transfer the ammunition technology produced failures and successes.

Only 5 days before the decision to adopt the French 75 mm caliber, the Ordnance Department had placed orders for 9 million rounds of 3-inch ammunition. These orders were halted pending

arrival and translation of the drawings for the French ammunition. But the American ammunition designers were due a surprise. Despite the fame that preceded it, the French shrapnel shell proved so distinctly inferior to the American that the Ordnance Department decided against interchangeability of this round.[25] (It is not clear whether interchangeability or interoperability was the intended word. The original report was written without benefit of today's refined lexicology of RSI. Many combinations of forging, casting, and machining methods were developed, and various materials and ogive shapes perfected, among the coalition armies to improve performance, especially range of the projectiles, most of which were interoperable.)

But more surprising, the French 75 mm high-explosive shell employed no bore rider safety in its fuze.[26] American designers considered such a fuze an absolute necessity, so had to make appropriate changes before accepting the round into service. Premature bursts did in fact occur with unfortunate frequency; this prompted a tactical change which staggered the guns in battery position, thereby protecting adjacent guns and gunners and, incidentally, improving the pattern of fall of shot.

The problem with drawings, to be a familiar problem in the ROLAND transfer, was also present in the French 75 transfer:

> To add to the confusion there were several different drawings of each component of the 75 mm high-explosive shell sent to the United States, and no member of the French Military Mission had definite information on which one was in current use in the French service. Officers had to be sent from France to advise on these matters. When 75 mm high explosive shells arrived from France as working models they did not conform to any of the drawings. The work of correcting and translating the French specifications of the 75 mm shells was not completed until December 1917.[27]

Meanwhile, in October of 1917, our now renowned "Big Red One" First Division entered the trenches in the Luneville sector of France. At 6:05 a.m. on the 23d of October, an American crew with the French 75 mm field gun Nr. 13579, today preserved aside the Plain at West Point, fired the first shot.[28] America had entered the war.

Transfer of the technology of the gun, the Puteux Arsenal unit trail carriage, and the Puteux recuperator continued apace in the face of a frantic attempt by US industries to catch up. Everything was in

short supply, from spruce for airplane wings to hickory for artillery wheels. United States industry had little experience with ordnance manufacture, and delays, overruns, and just plain failure to produce pieces that worked, plagued the mobilization effort.

Bethlehem Steel, for example, contracted to deliver fifteen 9.2-inch howitzers in 7 months, but took 16 months to produce only one. Midvale Steel, one of the few other companies with any ordnance experience, did not fare much better.[29] In hopes of improving the chances of delivery against schedules, the Chief of Ordnance implemented a policy requiring a second source for each critical item.[30]

Most officials expected the gun and carriage to be the most difficult to transfer, and difficulties there were, which were

> . . . aggravated by the necessary changes in drawings and shop practices, adopting . . . the metric system, changes in the projections of drawings due to different drafting-room methods in vogue in the two countries (first versus third angle projection as with ROLAND), and a lack of early appreciation of the different . . . relations between designing room and the shop. . . .[31]
>
> The screw threads on the gun carriage were not described on the French drawings and when examined on a French model were found to be of six different types and unknown to American Ordnance officials. Information requested from France reached the wrong agency in the Ordnance Department and was "lost" in the files until April 1918. When thread gauges arrived from France they did not correspond with the information in the French reply.[32]

United States manufacturers estimated 6 months would be required to replicate the French threads, so US threads were adopted instead. The British were forced to the same decision. But what proved most difficult to transfer was the recuperator, called variously on drawings, recoil, recouperator, *recuperateur*, brake, frein, cradle, sleigh, trainean, slides, and glissieres, none of which words was thoroughly descriptive.[33] French ordnance officers and government officials, aware of the distinction between craftsmanship and *le Systeme Taylor* of American mass production, advised their American counterparts "it would not be possible for (US companies) to educate (American) workmen to the quality of work necessary for the successful manufacture of these recouperators," that is, recoil and counterrecoil systems.[34]

The distinction between the French Puteux gun and the American 3-inch M1902, in fact the reason for the presumed superiority of the French model, lay in its hydropneumatic recuperator employing oil and air to absorb the shock of firing and to return the gun to battery. Despite the fact that the heat generated from firing the lengthy artillery preparations called for by the tactics of the time would cause the enclosed oil to boil, the precision Puteux recuperator continued to function impeccably. The United States, British, Italian, and German designs used a much simpler hydrospring recuperator employing a combination of pistons, springs, and steel tubing. It performed the same function, but not as well, and not as long. The Puteux secret was the use of a virtually self-contained large single heat-treated steel forging with a system of finely fitted surfaces and adjustment valves requiring highly skilled craftsmen to produce and maintain.

Manufacturing the recuperator proved so difficult that the US Ordnance Department decided to build the guns and carriages in form and fit to accommodate French-produced recoil mechanisms, and ship the parts to France for assembly with French-produced recuperators. Later, US foundries would forge and rough turn the recuperator forgings to send to France for finishing, but not until April of 1919 would acceptable finished recuperators be produced at US factories—Rock Island Arsenal and Singer Machine Company—at an acceptable rate, 4 months after the Armistice was signed.[35]

The confusion was exacerbated by the press of a shooting war in that differing proposals came forth from the combat development/ research and development community and from the "user." The Chief of Artillery wrote protesting the original order of the M1916 split trail carriages because field testing proved the design unsatisfactory. He proposed instead that the United States adopt the British Model 1917, then in production at Bethlehem Steel.[36] Yet most officers seemed to agree that the British carriage was the worst design available. The Commandant of the Artillery School proposed differently, suggesting that if the M1916 split trail was not forthcoming, the US 3-inch M1902 (rebored to 75 mm for interoperability) be adopted.[37]

In the meantime, American forces, supported by their 75 mm field guns, went on to great victories, stopping the Germans in the Aisne Marne and Chateau Thierry and passing over to the offensive against the Hindenburg Line and in the Meuse-Argonne sector. United States efforts to accomplish the split trail design, and to

simplify the recuperator continued unabated and eventually succeeded, combining the M1916 carriage with a simpler recuperator mechanism developed at the St. Chamond Company, for which Major Hillman had negotiated production rights. The United States was seeking a design that could be repaired in the field by our mobile support units. The French were satisfied with sending their weapons back to the factory for repair. Pershing's staff was to add to the confusion by first advising against the St. Chamond recuperator, then later being for it.[38]

Conflict and confusion likewise derived from testing and from troop preference for one or another tactical practice. In a memorandum to the Chief of Artillery, Colonel Fleming, Commandant at Fort Sill, wrote that the comparative tests of the US M1902 and French 75 were slanted to "confirm the idea that the 75 mm was a superior weapon" by using targets and exercises favoring the French gun. Adaptations of US firing practices or selection of other targets and exercises, he claimed, would have shown the US gun as good as or better than the French 75.

Tactical preferences among different armies and their effect on weapon design such as occurred with ROLAND'S radar tracker likewise occurred. Continuing his report, the Commandant noted that the M1902 had "sighting, shield, and draft arrangements . . . distinctly superior to the French" which should be applied to the French model in any case if the French 75 is made in the United States, because the US sights were considered more suitable for American tactics.

Sights were totally different on the British gun. The British Army did not initially intend to employ the new indirect fire methods for light artillery, so the British version M1917 75 mm retained its simple direct sight. British officers, armed only with swagger sticks, leading their troops over the top, considered the tactics of hiding one's guns behind hills not quite cricket, and were not wont to clutter the battlefield with messy arithmetic.

National preferences for handling ammunition and servicing the piece likewise were reflected in caisson and limber design, though minor modifications to lunettes made them at least interoperable.

The guns went on firing as the Allies crushed desperate efforts of the German Army to hold on. Pershing was certain victory was near and, as French production slowed due to crushing shortages of manpower and materials, plans were made to introduce US-

manufactured weapons for a new offensive. But the carnage spewed out by these fast-firing guns eventually brought the nations to their senses and the war to an armistice. Efforts with the French 75 were redirected to relining worn-out barrels, developing pneumatic carriages for high-speed towing behind trucks and even mounting the gun on a self-propelled carriage. On the one hand, the war took so heavy a toll of horses that transport was given top priority at US ports to replace the horses with trucks. On the other, the mobility of the infantry due to their own motorization demanded a similar incremental increase in speed on the part of artillery. The French developed a U-shaped trail to try to obtain the elevation of the US M1916 carriage, but without its complexity.

Before World War I public perception held that since the industrial effort for war would be so enormous, industry could not sustain the frantic pace for more than 10 days; ergo, war could not occur. Consequently, the French decision to pursue standardization at the cost of five 75 mm guns per day was exceptionally grave. Yet the decision to manufacture weapons in the United States for training and to use French materiel in France, apparently made at a meeting in May 1917, was initially applauded by all concerned. The decision to adopt French calibers (75, 105, 155mm) made in June of that year, and the decision to replicate the Puteux Model made in February 1918 were likewise widely applauded at the time. As problems emerged and the Armistice found virtually no US production of the Model 1897 completed, controversy reared its head that was to continue long after the shooting came to a close. Everyone had an opinion. But the achieved uniformity of ammunition played a significant role in the victory. Continuing controversy served only the external and internal politics of the War Department and public figures.

In a personal letter regarding his book, *Ordnance and the World War* written to the Director of the Army Industrial College, General Crozier, from the vantage point of 1934 opined that it would have been better to have stuck with the M1902 (rebored to 75 mm as the book supports),[39] and to have pressed on separately with the M1916 split trail. Though time and circumstances have changed to a degree, General Crozier's advice to pursue interoperability and excellence of design first over the political, economic, and vague military-politico advantages of interchangeability makes good sense.

There are, of course, many differences between today's level of ability to achieve international standardization and the ability present in 1917. Recognized standards for taps, dies, and performance

specifications, for example, have emerged, impelled particularly by the burgeoning automotive industry which was then in its infancy. Those basic systems are just the beginning of a long list of standards now internationally in use. But some problems have been exchanged for others: metrification, so difficult for the French 75, was not difficult at all for ROLAND, and Dickinson, in his Ordnance Corps report, used sentences in French which he did not bother to translate—presumably, any American in a position to read his report read French. The only language problem identified was that of a multiplicity of terms for the recuperator. The two problems today have exchanged places.

As noted, similar problems of technology transfer were to recur in World War II, during efforts to transfer manufacturing capability from the aircraft to the automotive industry to build B-24 Liberators, for example. Similar problems occurred even in transferring production from plant to plant within the aircraft industry. But with each transfer in the United States, lessons were learned to apply to the next. Today, if RSI is to succeed, we must extrapolate the lessons learned NATO-wide from each civil and military industrial experience.

Several "lessons learned" documents have been prepared by ROLAND participants. Their treatment of specific details is such that they must be classified Confidential. In general terms, they differ little from the story of the 75. For policymakers who poke a finger into the "Nebula Pentagona," the most useful lesson learned lies in these general patterns of behavior which determine where the volume displaced by new policy will bulge.

As this monograph shows, there are patterns of organizational proclivity. Troops prefer the familiar. Engineers prefer the novel. There are standard rules of engagement in bureaucracies, nationally and internationally; in the tactics and doctrine development realm; and in the research and development communities which come into play. And there are standard tendencies among potential contractors and proponencies to overestimate simplicity and underestimate cost. If a policy to improve NATO rationalization, standardization, or interoperability is to be successful, it should at least accommodate the institutional and societal dynamics so that the less structured problems of the moment can be engaged.

CHAPTER IX ENDNOTES

1. I. B. Holley, *Buying Aircraft: Air Materiel Procurement for the Army Air Forces In World War II* (Washington, DC: Government Printing Office, 1963).

2. W. N. Dickinson, *The Story of the 75 (75 mm field gun),* Army Ordnance Report No. 1862 covering 1917-1919 (Washington, DC: Government Printing Office, 1920), p. 5.

3. Ibid., p. 91.

4. B. Crowell and R. F. Wilson, *The Giant Hand,* pp. xiv, quoted in H. A. De Weerd, "American Adoption of French Artillery, 1917-1918," *American Military Institute Journal* 3 (1939): 107. Establishing the National Defense University with the university function of exchange and publication of information may help preclude a future similar shortcoming. The University comprises The National War College and the Industrial College of the Armed Forces.

5. De Weerd, "American Adoption of French Artillery," p. 108. The policy of assigning officers of all branches of service to attache positions today enhances both representative and diplomatic reporting functions.

6. Ibid., p. 105ff.

7. Ibid., p. 108.

8. Ibid.

9. "The Production of Munitions, a Statement of War Department Policy," *Army Ordnance Magazine,* January-February 1935, p. 201.

10. De Weerd, "American Adoption of French Artillery," p. 110.

11. Major General William Crozier, *Ordnance and the World War* (New York: Charles Scribner's Sons, 1920), p. 219ff.

12. LTC Marvin Kreedberg and lst Lt Merton Henry, *History of Military Mobilization in US Army 1775-1945,* DA Pamphlet 20-212, Headquarters, Department of the Army, November 1955, p. 322.

13. General Gascouin, *L'Evolution de l'Artillerie Pendant la Guerre (Paris: Ernest Flammarion, 1920), p. 25.*

14. *Crozier, Ordnance and World War,* p. 211.

15. Ibid., p. 205.

16. Ibid., p. 18. His rationale is the same as today's.

17. Dickinson, *Story of the 75,* pp. 8-9.

18. In a tall glass blend 1 jigger gin and 1/3 jigger lemon juice with 1 teaspoon powdered sugar. Half fill the glass with cracked ice and fill it with champagne. *The Gourmet Cookbook,* vol. 2 (New York: Gourmet Distributing Corporation, 1959), p. 24. The author attests to the high calibre but bears no responsibility for results on impact.

19. Crozier, *Ordnance and World War,* p. 235.

20. Ibid., p. 14.

21. Ibid., p. 15.

22. Dickinson, *Story of the 75,* p. 107. Technology transfer occurs in many strange ways. In France, one of the developers of the Puteaux gun designed a split trail carriage which the French Army did not buy because of high costs. The inventor sold his design to the Italians who in 1913 sent it to the United States for testing. The same designer, Albert Deport, was contracted privately by US Ordnance to develop the recuperator designated St. Chamond. See Major W. J. Savoy, "The Evolution of the American Modern Light Field Gun," a master's thesis, USACGSC, Defense Documentation Center (DDC) ADA058332.

23. Ibid., p. 107ff.

24. Ibid., p. 6.

25. De Weerd, "American Adoption of French Artillery," p. 110.

26. The "bore rider safety" is a spring-loaded pin which interrupts the firing train of the fuze, preventing premature detonation from the setbacks forces of firing the gun. Upon firing, the spring pushes the

pin against the barrel. When the projectile leaves the gun, the pin flies out and the fuze becomes fully armed.

27. De Weerd, "American Adoption of French Artillery," p. 111.

28. Dickinson, *Story of the 75*, p. 59.

29. De Weerd, "American Adoption of the French Artillery," p. 109.

30. Dickinson, *Story of the 75*, p. 8.

31. Ibid., p. 91.

32. De Weerd, "American Adoption of French Artillery, p. 113.

33. Dickinson, *Story of the 75*, p. 34.

34. Ibid., p. 107.

35. Crozier, *Ordnance and World War*, p. 240.

36. Dickinson, *Story of the 75*, p. 92.

37. Memorandum, School of Fire for Field Artillery, Fort Sill, Oklahoma, 15 March 1918, quoted in Dickinson, p. 30.

38. De Weerd, "American Adoption of French Artillery," p. 112.

39. Letter, Brigadier General Crozier to Colonel Harry Jordan, Director, Army Industrial College, 25 November 1934. (The letter was glued to the cover of the book by a thoughtful librarian. The book itself, printed in 1920, was accessed by the College Library in 1928; Good work!)

APPENDIX A. SYSTEM DESCRIPTION

General

ROLAND II is a highly mobile, low-altitude, all-weather, air-defense missile system. The system was designed and developed by the Franco-German industrial team (Euromissile) to be a fully integrated missile launching and fire control station mounted on a single self-propelled vehicle.

US ROLAND is the American adaptation of European ROLAND II technology and is being produced to meet the US Army's requirement for defense of high value fixed assets against all-weather, low-altitude air attacks. US ROLAND is a complete weapon system consisting of a fire unit, missile rounds, and maintenance and training equipment.

Fire Unit and Carrier Vehicle

The fire unit is a self-supporting, fully integrated fire control and missile launch station mounted in a module configured for transport by various Army vehicles or to stand alone in a fixed installation. The presently planned prime mover for the 11-ton fire unit module is a derivative of the M-109, self-propelled howitzer vehicle chassis. Each fire unit carries a basic load of 10 missiles, 2 mounted on launchers, and 8 stored in magazines ready for rapid, automatic reload of the launchers. The crew consists of four men: commander, gunner, assistant gunner, and vehicle driver.

Major components of the fire unit are: the surveillance radar with integral identification friend or foe (IFF); the radar and optical tracking systems; the missile guidance command computer and radio frequency (RF) command link; missile launchers, storage magazines, and associated automatic reload equipment; prime power and environmental control units; built-in test equipment; the commander and gunner stations; and the logic unit with associated electrical and hydraulic subsystems necessary to integrate the system.

SOURCE: US ROLAND Project Office, US Army Missile Research and Development Command, Redstone Arsenal, Alabama.

Missile

The US ROLAND missile is a command-to-line-of-sight (CLOS) guided missile weighing approximately 145 pounds. The missile is packaged as a round of ammunition, sealed with wings folded in its launch tube at the factory. This eliminates the need for missile maintenance and reduces logistical handling requirements. The missile employs boost-sustained propulsion and contains both contact and proximity fuzing to initiate detonation of the multiple shaped charged warhead.

Support Equipment

The US ROLAND maintenance concept consists of three levels of field maintenance equipment: Built-in Test Equipment (BITE) used to perform operator/crew maintenance; an Organizational Maintenance Test Set (OMTS) used to perform organizational maintenance and to equip members of a maintenance support team; and a Field Maintenance Test Set (FMTS)—direct support maintenance. System items not repairable at one of these levels will be evacuated to depot for repair.

The US ROLAND BITE consists of built-in equipment (lights, meters, etc.) which allow crew members to assess the operational status (on a GO/NO-GO basis) of the major system components. Some manual adjustment of tunable assemblies and override of NO-GO status are also provided. Crew member repair capabilities are limited to minor items such as bulbs and fuzes.

The US ROLAND OMTS is European-designed and consists of a series of 15 suitcase packaged portable test units with associated fixtures and cabling designed to augment BITE by plug-in at the fire unit. The OMTS has the capability to isolate faults to the replaceable subassembly/box and to verify system repair by replacement. The OMTS and maintenance support team personnel will be transported to the fire unit in an M880 1 1/4-ton vehicle-mounted S250 electronics shelter.

The US ROLAND FMTS is US-designed and consists of two integrated automatic test stations installed in two M373 semi-trailer vans. Special tools for the system will be transported in two M35A2 cargo trucks. Hydraulics, power equipment, and environmental equipment will be supported by a shop housed in an S280 shelter mounted on a 2 1/2-ton vehicle. The FMTS is capable of fault isolation

within a subassembly/box, repair by component replacement with repair verification, and required system adjustment, alignment, and calibration.

Training Equipment

Two training devices comprise the US ROLAND training equipment: an operator/crew proficiency trainer, and a training missile. Both items are designed for use with the fire unit.

The operator/crew proficiency trainer consists of an instructor's console, a video tape rack, and a storage cabinet installed in a 2 1/2-ton vehicle-mounted S280 electronics shelter. The trainer inputs simulated target engagements and other combat training exercises into an operational fire unit.

The training missile is a ROLAND missile launch tube weighted and balanced to simulate the tactical configuration. The missile is used to facilitate fire unit crew resupply training and support personnel handling, magazine, and launcher operation training.

APPENDIX B. GLOSSARY OF ACRONYMS

ADPA	American Defense Preparedness Association
ADRES	Army Data Retrieval Engineering System
ASARC	Army System Acquisition Review Council
ASPR	Armed Services Procurement Regulation
BAC	British Aircraft Corporation
BITE	Built-in Test Equipment
BPFA	Bureau de Programmes Franco-Allemand
CDRL	Contract Data Required Documents List
CLOS	Command-to-Line-of-Sight
CRG	Configuration Review Group (JRCC)
CSCS	Cost Schedule Control System
DA	Long Range Aviation (USSR)
DARCOM	Army Materiel Development and Readiness Command
DDR&E	Director of Defense Research and Engineering
DOD	Department of Defense
DSARC	Defense System Acquisition Review Council
ECCM	Electronic Counter Counter Measures
ECM	Electronic Countermeasures
EEC	European Economic Community
FA	Frontal Aviation (USSR)
FAADS	Field Army Air Defense Study
FMTS	Field Maintenance Test Set
GAO	General Accounting Office
GSFG	Group of Soviet Forces Germany (Warsaw Pact)
HIREL	High-Reliability
IFF	Identification Friend or Foe
JLS	Joint Logistics Subcommittee (JRCC)
JRCC	Joint ROLAND Control Committee
JTNGS	Joint Training Subcommittee (JRCC)
JTS	Joint Test Subcommittee (JRCC)
LOFAADS	Low Altitude Field Army Air Defense System (USA)
LTDP	Long Term Defense Program
MBB	Messerschmitt-Bolkow-Blohm (Munich, Germany)
MC	Military Characteristics
MENS	Mission Element Need Statements
MICOM	US Army Missile Command
MILSPEC	Military Specifications
MILSTD	Military Standard
MOU	Memorandum of Understanding
NATO	North Atlantic Treaty Organization
NBMR	NATO Basic Military Requirement

OCRD	Office of the Chief of Research and Development, US Army
OJCS	Office of the Joint Chiefs of Staff
OMTS	Organizational Maintenance Test Set
OR/SA	Operations Research/Systems Analysis
OSD	Office of the Secretary of Defense
PERT	Program Evaluation and Review Technique
PM	Project Manager
PMO	Project Management Office
PVO Strany	Air Defense of the Nation (USSR)
PVO SV	PVO of the Ground Forces (USSR)
QMR	Qualitative Materiel Requirement
R&D	Research and Development
RDT&E	Research, Development, Test, and Evaluation
RF	Radio Frequency
RFP	Request for Proposal
ROC	Required Operational Capability
RSI	Rationalization, Standardization, and Interoperability
SAM	Surface-to-Air Missile
SCCS	Simulation Central Coordination Subcommittee (JRCC)
SHORADS	Short Range Air Defense Study
SNIAS	Societe Nationale Industrielle Aerospatiale (Paris, France)
SSEB	Source Selection Evaluation Board
TACRAC	Technical and Cost Reduction Assistance Contract
TDP	Technical Data Package
TRADOC	US Army Training and Doctrine Command
TSC	Threat Subcommittee (JRCC)
TSM	TRADOC System Manager
TTF&T	Technology Transfer, Fabrication, and Test
VA	Air Army (USSR)

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